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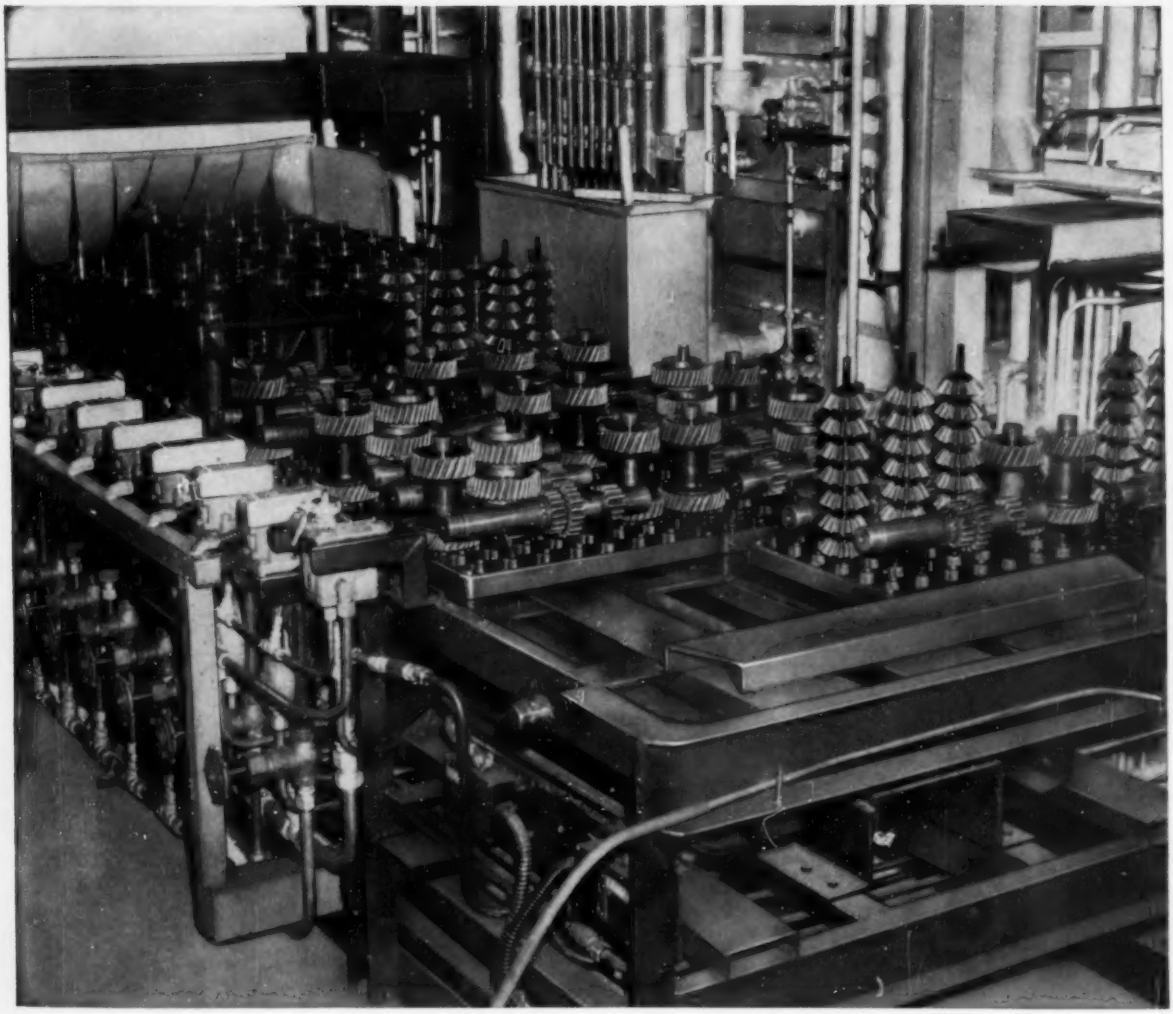
# Metal Progress

JANUARY 1957



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# Metal Progress

Volume 71 No. 1

January . . . 1957

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HAROLD J. ROAST, E. C. WRIGHT and J. L. MCCLOUD
*Consulting Editors*

MARJORIE R. HYSLOP
*Managing Editor*

**Annual International Review of Metallurgy**

**Enriched Blast in Basic Steelmaking, by Pierre Coheur and H. Kosmider** ..... 67

Europeans find that the use of oxygen-enriched blast with or without supplementary oxygen through the converter's mouth speeds the steelmaking process, consumes more scrap, utilizes offgrade pig iron, and broadens the applications of the steel produced. (D 3, ST)*

**Expansion of Steel Industry in India, by V. S. Swaminathan** ..... 73

Nearly a billion dollars has been allocated to expand Indian steel production from the present 1,300,000 tons to 5,500,000 by 1961. The privately owned Tata and Indian Iron and Steel Companies are financing 1,100,000 tons of this expansion. Three new ones, each of 1,000,000 ingot tons capacity, will be run by the Government; one built by the Russians, one by West Germans, and one by the English. (A 4, D general, ST)

**Development of the Aluminum Industry in Austria, by Eduard Nachtigall** ..... 77

Now that Austria has regained control of her aluminum industry, several special products for consumers have been devised, including siding and roofing, snow fences, electrical conductors, nails and deep drawing sheet. (A 4, T general, Al)

**International Progress in the Light Metal Industry, by Francis C. Frary** ..... 81

Reports presented at the Third International Light Metal Congress indicate the tremendous expansion in world-wide production and use of the light metals. (A 4, Al, Mg)

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**Quality Control of High-Temperature Alloys, by G. T. Harris** ..... 90

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**Influence of Residual Stress on Hardness, by P. A. Blain** ..... 99

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METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00 . . . The A.S.M. is not responsible for statements or opinions in this publication.

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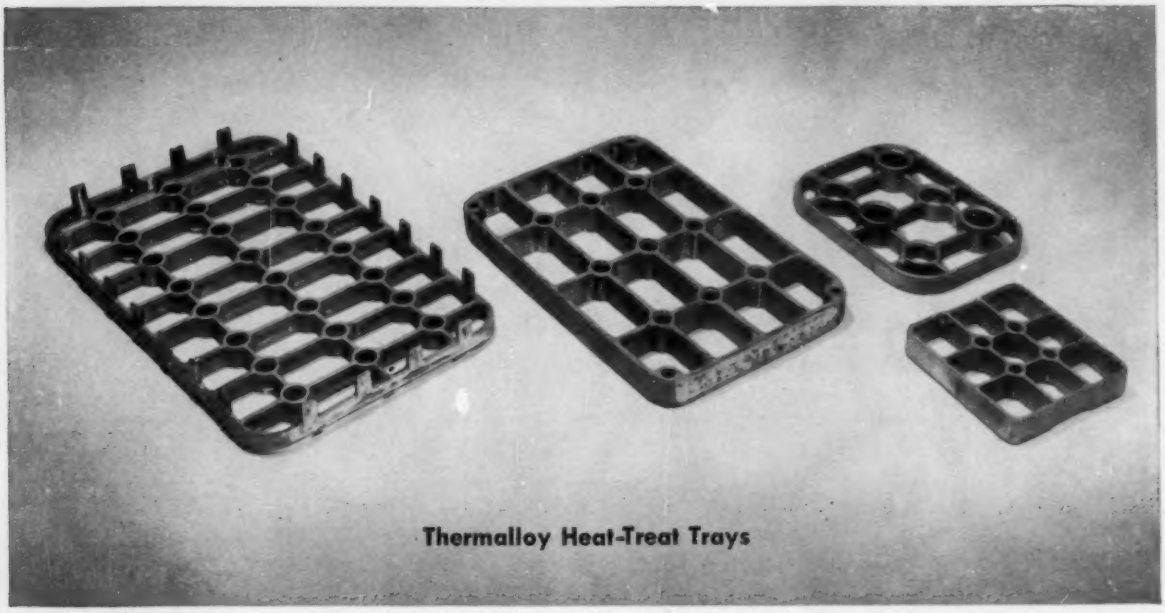

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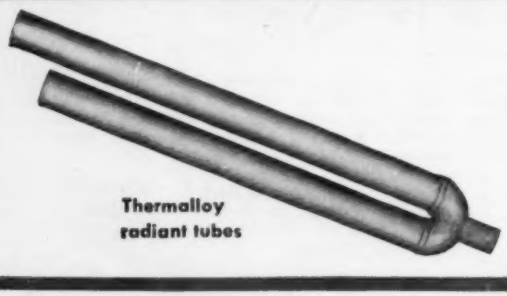
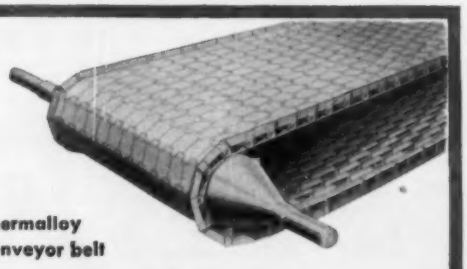


Thermalloy radiant tubes



Thermalloy conveyor belt

# Metal Progress

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# As I was saying...

— when this shot was shot at my home chapter (Cleveland) meeting — one of the nicest things about being Secretary is the opportunity to visit the chapters and talk to the membership.

In the earlier days when the A.S.M. was growing I could visit all the chapters in a year but now the 101 chapters present an impossible project not only for the Secretary but for the President as well.

At the last meeting of the A.S.M. Trustees the Secretary was instructed to study the possibilities of dividing the chapters into four or five groups so that in a period of four years all the chapters would have a presidential visit.

Using the present system whereby the President visits chapters to which he is invited, a few chapters have the President every year and many chapters have this honor very infrequently. Not only is this an injustice to many chapters, but the travel time of the President becomes excessive, as he swings from here to there and then back again — an aggregate of time greater than the Society should require from its head officer. So now we are gathering information on the chapters' regular meeting nights and may soon present to the chapters a Board-approved plan for presidential visits.

I thought I heard you ask "How is the new headquarters building coming along?" Well, I'll answer that $64 thousand question by a chronological report. After the selection of the architects (Skidmore, Owings & Merrill) a team came to headquarters and spent a few days studying the "flow of traffic", the requirements of the departments, possible future expansion of space requirements, and a visual study of the 100-acre site to determine a master plan for all the buildings of the A.S.M. of Tomorrow.

At the next meeting the architects brought with them a master plan and wash-drawing of a suggested type of building. We had a staff committee composed of heads of departments which outnumbered the architects' team so we tore the submitted proposal apart (constructively, we hope). The architects retired and came back in two weeks with another master plan and further suggestions for the outside appearance of the building and the inside arrangements. This time the master plan mustered approval of the staff committee and is now ready to be passed on to the Board for consideration. The building sketch was sent back for further study and more complete details and if possible an entirely different approach, so that the staff committee and the Board might have at least two proposals from which to make a selection.

So there is the picture of how things are going now. If the staff committee gets something that pleases them both from external and internal design and arrangements, a special meeting of the Trustees will be called by President Don Clark.

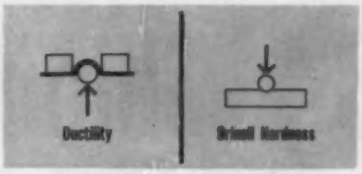
We are making progress slowly but we are all striving most sincerely to have a building of which all of you will be very proud and which will serve to set the pattern for the many other buildings that will follow to create the Metal Science Center of the A.S.M. of Tomorrow.

As I was saying, may you and your dear ones all have a Happy New Year. May you prosper abundantly and have good health through 1957 and all the years to come.

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS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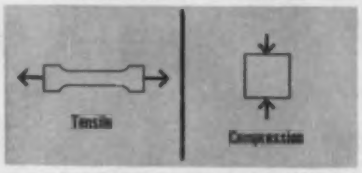


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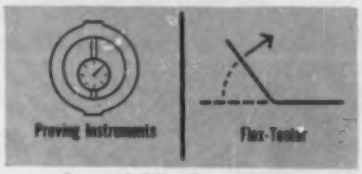


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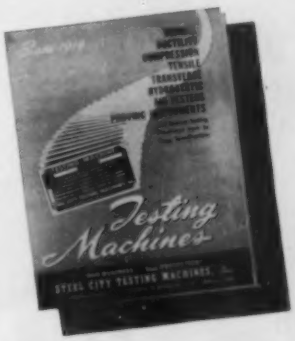


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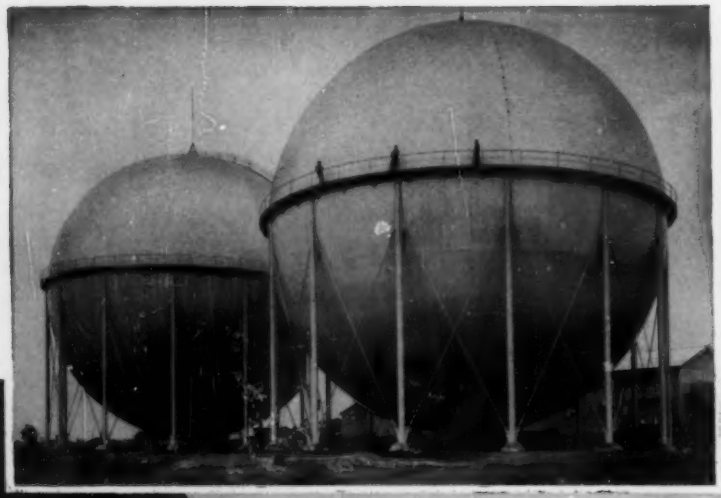


**HIGH WORKING STRESS.** These vessels are of Chicago Bridge & Iron Company's Hortonsphere construction. They were designed for storing natural gas at a pressure of 71.1 psi in Tokyo, Japan . . . with an earthquake factor of 0.30 and wind pressure of 26 lbs. per sq. ft. on the projected spherical area. USS "T-1" Steel vessels were built to a maximum allowable working stress of 36,000 psi with 90% weld joint efficiency. This stress is about one-third of USS "T-1" Steel's ultimate tensile strength. Each vessel is supported by 14 tubular columns, 18 inches in diameter. The top portion of each column, which is welded to the sphere, is made of USS "T-1" Steel. The columns rest on 14 concrete piers which are interconnected by reinforced concrete struts. Chicago Bridge & Iron Company is now fabricating steel for two additional, slightly smaller vessels of similar construction for Tokyo Gas Works, Ltd.

# in Two Giant Pressure Vessels by using USS "T-1" STEEL!

**Six conventional pressure vessels would have been required** to provide the same capacity, under the same pressure, as these two natural-gas storage tanks made from USS "T-1" Steel.

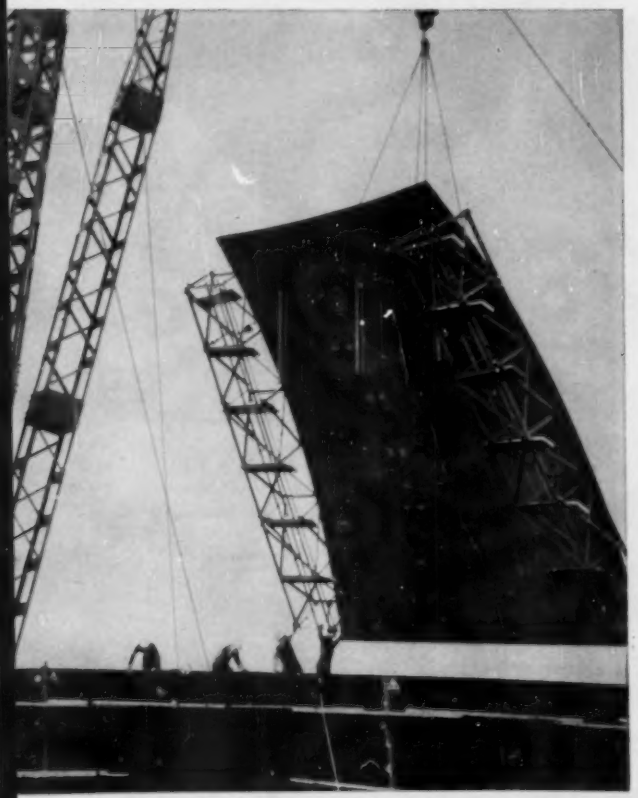
The six conventional vessels would be built with structural carbon steel which has a yield strength only one-third as great as USS "T-1" Steel. As a result, the maximum size of each vessel would be restricted . . . the shell walls would have to be thicker . . . and the six vessels, together, would weigh nearly 2½ times as much as the two vessels that were actually built with USS "T-1" Steel.

The six conventional vessels, being heavier, would have required more foundation material and supports . . . would have been more expensive to ship, to handle, to erect . . . and would have occupied much more ground area.

USS "T-1" Steel—with a yield strength of 90,000 psi—was the only existing steel from which the two large vessels could have been built economically. Structural carbon steel is not strong enough. High alloy steels are not easy to weld—and they cost more than USS "T-1" Steel. USS "T-1" Steel has *both* the extra strength and the excellent weldability that are needed.

These two vessels were built for Tokyo Gas Works, Ltd., Tokyo, Japan, under the supervision of erection engineers of Chicago Bridge & Iron Company. Chicago Bridge & Iron also designed the vessels and fabricated the steel.

**NEW BOOKLET AVAILABLE!** Our new revised booklet on USS "T-1" Steel gives you complete facts about the application of this remarkable steel. Much new information has been added on welding and fabrication, and all other information has been brought up to date. If you design steel structures, you need this booklet. Write, today, for a free copy. Or get in touch with the nearest USS Sales Office. United States Steel, Room 2801, Pittsburgh 30, Pennsylvania.



**FIELD WELDING.** Each vessel contains 188 separate USS "T-1" Steel plates (Quenched and Tempered, Firebox Quality), 0.73-inch thick, which were welded in the field with E12016 electrodes. All welds were 100% X-Rayed. The steel was fabricated by Chicago Bridge & Iron Company in Greenville, Pennsylvania. All fittings—including two 16-inch nozzles, two 20-inch manways and many smaller nozzles—were forged from USS "T-1" Steel billets.

**A COMPARISON** of two typical methods of constructing these Japanese pressure vessels: one, with USS "T-1" Steel, and the other, with structural carbon steel, is shown in the following chart, courtesy of Chicago Bridge & Iron.

| | USS "T-1" Steel Full X-Ray Required | Structural Carbon Steel Full X-Ray 90% Joint |
|---|---|---|
| Pressure | 71.1 | 71.1 |
| Stress (psi) | 32,400 | 13,500 |
| Diameter (Ft.) | 110.5 | 79.17 |
| Wall Thickness (In.) | .73 | 1.25 |
| Geometric Volume (Cu. Ft.) | 707,000 | 260,000 |
| Weight (Each Vessel) Tons | 625 | 545 |
| Number Of Vessels Required To Provide 1,414,000 Cu. Ft. Geometric Cap. | | 5.45 |
| Total Weight Tons (All Vessels) | 1,250 | 2,970 |
| Weight Saving Using "T-1" Steel (Million Pounds) | 3.44 | |

## USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

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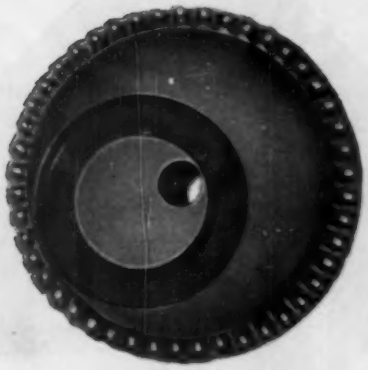

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199


## METALS AND ALLOY REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

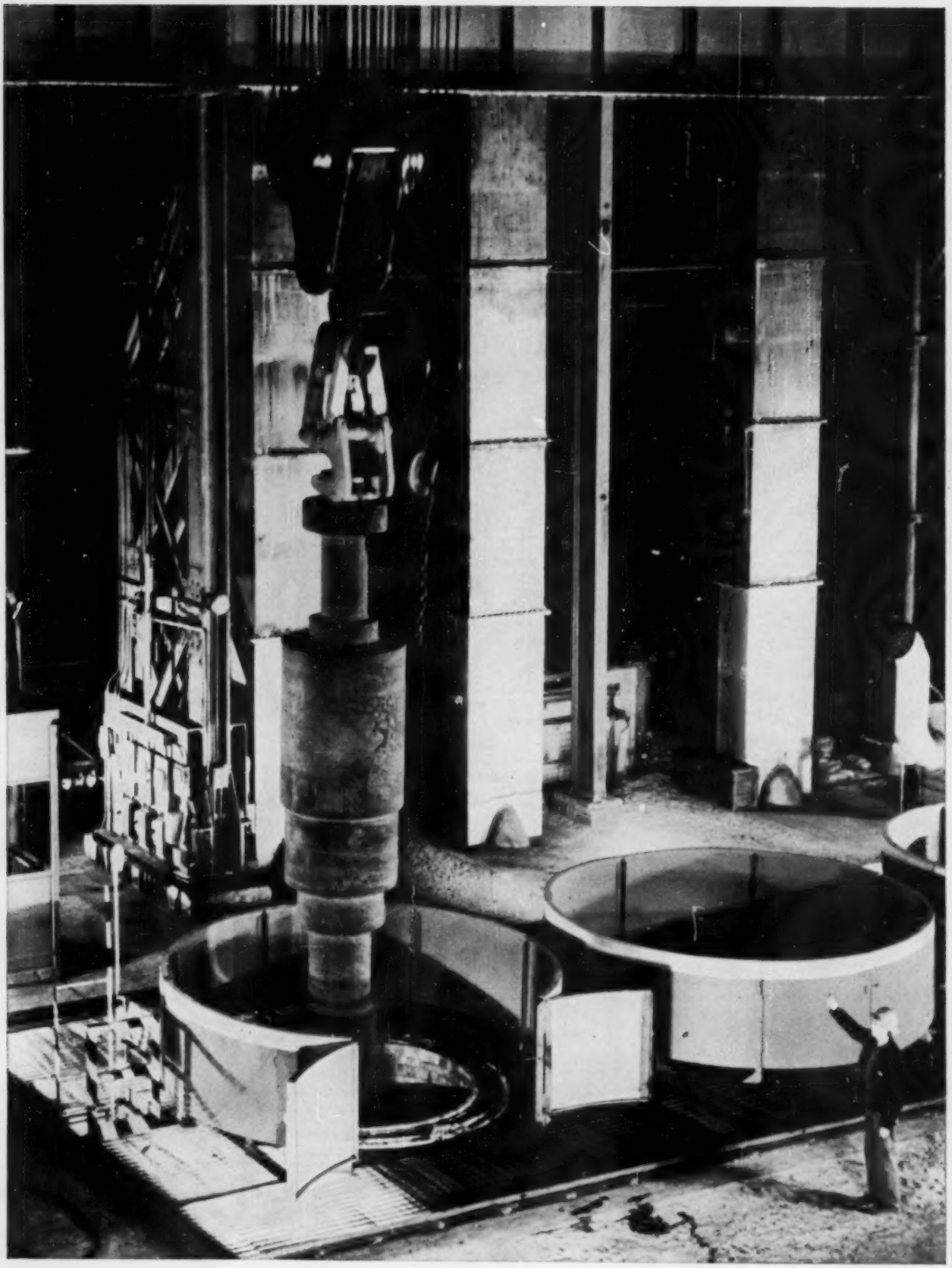
Recently Ray Engelgau, who heads our statistical quality control procedures, and Amos Armitage from our machining department met in my office and we had a very interesting discussion on our new "S-C" rod. The term "S-C" is derived from the fact that it is produced from billets that are cast semi-continuously. In addition, we use the letters "S-C" to indicate its "super cutting" qualities which is one of the outstanding characteristics of this rod. We have definitely proved these qualities in some very exhaustive tests, one of which I'd like to tell you about here.

Experience has shown that it is difficult to control dimensions within close tolerances on machine parts involving internal forming operations. Amos had run into exactly that trouble with a certain hydraulic fitting made from rod that required a fairly close dimensional tolerance on the internal formed diameter. So, we decided to make a comparison test by machining the part from rod made by the conventional method and from rod produced by the S-C process. When rod made by the conventional method was machined, the parts could not be held within the specified tolerance range. The same machine, the same tooling and the same machine operator were used in this test, and when S-C process rod was substituted, the machine parts were well within the required tolerance range.

In addition, I just received a letter from a well-known equipment manufacturer who has been running tests on S-C rod. They reported that the incidence of tool trouble per 1000 forgings machined from S-C rod were approximately half that of forgings made from conventional rod. We think that is pretty good evidence that the rod made by our semi-continuous process is exceptionally uniform by all standards. Incidentally, our new billet casting department is quite a model of automation and has a number of interesting processes and features. Anytime you happen to be in our area we would be more than happy to show you through and explain the many points of this process that gives us what we firmly believe to be the best possible rod available today which of course is reflected in the quality of our forgings.

If you would like a folder that fully covers our semi-continuous process, just drop me a note and I'll see that one is sent along to you promptly. In the meantime, we'd like to have you investigate our super-cutting S-C rod because we think it will improve your product quality—and we've got the alloys to do most anything to meet the most exacting demands.

Thanks for your time.



# Giants, too, heated without distortion

*Westinghouse pressurized furnaces keep 30-ft forgings "straight as an arrow" at U. S. Steel*

Three large, Westinghouse pit-type furnaces at U. S. Steel's Homestead Works are built to pamper giant forgings. This turbine rotor, for example, lifts out straight and true at 1830°F. During eight hours of soaking heat the temperature along its 30-foot length never varied as much as 10°F. Distortion was never a problem because of Westinghouse temperature control and positive pressure furnace design.

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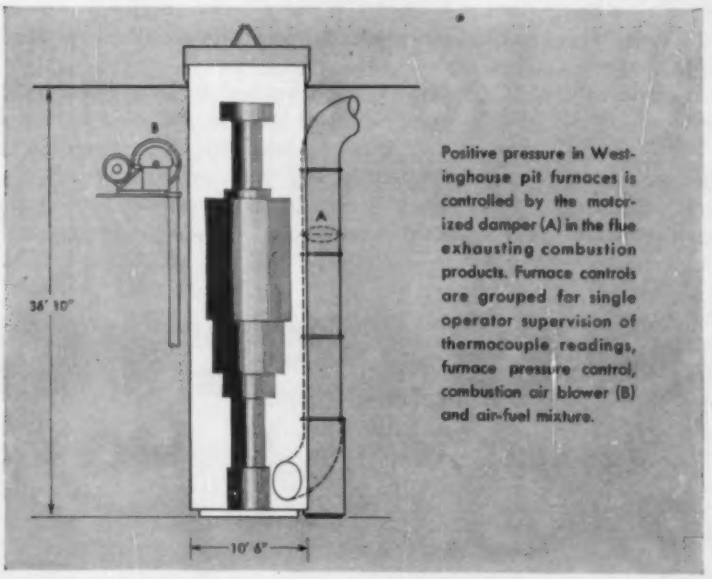
**Westinghouse**




Positive pressure in Westinghouse pit furnaces is controlled by the motorized damper (A) in the flue exhausting combustion products. Furnace controls are grouped for single operator supervision of thermocouple readings, furnace pressure control, combustion air blower (B) and air-fuel mixture.

*W. E. Collar* reports . . .*

## Facts to lick your distortion problem

Unusual facilities and experience at Westinghouse have enabled us to jump years of trial-and-error methods in engineering furnaces and induction heating equipment to prevent distortion. We're constantly after better ways to gain temperature uniformity in metal processing equipment. This is necessary not only to prevent distortion but also to obtain desired metallurgical properties.

On special problems, our equipment design engineers have the advantage of facts gained through Westinghouse metallurgical research activities. Production testing of equipment design and engineering is carried out by our Materials Manufacturing Division at Blairsville, Penna. These activities back up our long experience in gaining accurate heat distribution for positive temperature uniformity.

The results can be seen in a Westinghouse furnace used for the air tempering of rotors for atomic equipment. Accurate heat control designed into this electrically heated furnace meets demanding requirements for distortion-free work.

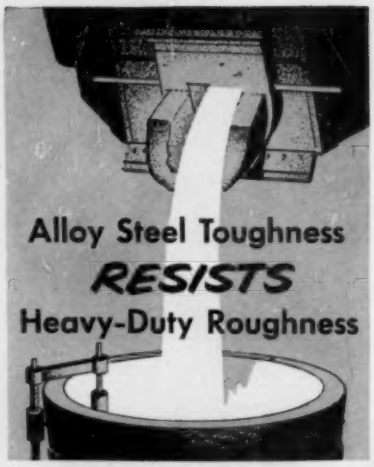
Another case in point is the work on distortion problems under way in our induction heating laboratory. Here equipment is being developed for distortionless hardening of automotive axles.

The teamwork that solved these application problems is your assurance of getting the latest in engineering development and the finest equipment for all your metal processing needs.

**Manager, Industrial Heating Dept.*

*The Westinghouse Heat-Treating Family*

GAS • ELECTRIC • INDUCTION



• Landing-gear strut for the North American F-100C is manufactured by Bendix Products Division, Bendix Aviation Corporation. Exacting requirements for inner and outer cylinders resulted in the development of a new grade of steel by Bendix and Republic metallurgists working in cooperation with North American engineers.

## How Metallurgical Teamwork Developed the Super Sabre's Tough,

When a new grade of steel is born, there's sure to be an interesting story behind it.

In this case, it's the story of close cooperation between metallurgical teams from Bendix and Republic. Their common goal: development of a tough, strong, alloy steel to withstand the shock, impact, strain and vibration of tons of aircraft hitting the runway at speeds in excess of 100 miles per hour.

It starts after World War II, when Bendix metallurgists undertook a program to correct certain characteristics and improve processing deficiencies of steels commonly used for aircraft landing gear.

Several leading steel companies, including Republic, were consulted and the program outlined. Republic immediately put its 3-Dimension Metallurgical Service Team on the problem.

The field metallurgist worked closely with Bendix metallurgists and engineers right in their own plant under actual operating conditions. Their findings were supplemented and coordinated by the other two members of the Republic team—the laboratory and mill metallurgists.

The result: development of a new grade of steel that

**REPUBLIC**

REPUBLIC STEEL

*World's Widest Range of Standard Steels*

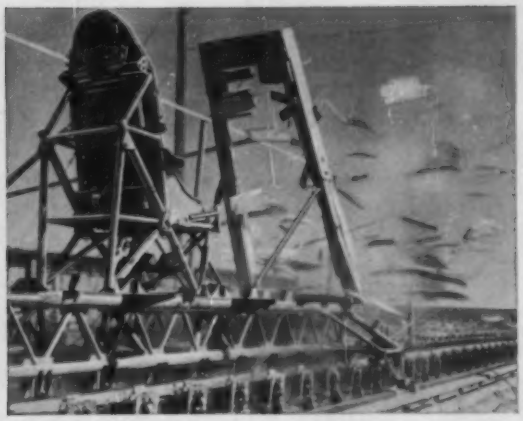
## Strong, Alloy Steel Landing Gear

was found ideal for application in the strength range of 220,000-240,000 psi. This steel, designated AMS 6427 by the SAE, offers maximum resistance to fatigue. Provides an exceptionally high strength-to-weight ratio. Maintains its great strength at wide temperature extremes. Responds uniformly to heat-treatment, producing hard, wear-resistant surfaces around tough cores.

Are you sure you are using the right steel? Why not make sure by using Republic's 3-D Metallurgical Service to assist you in a check-up? It's confidential. There's no obligation. Just send us the coupon.

# STEEL

*and Steel Products*



**WHERE STRENGTH IS AN IMPORTANT REQUIREMENT**—such as this rocket sled for deceleration tests—manufacturers choose tubing for basic construction. At any given weight, tubing is strongest of all mechanical shapes . . . as a beam . . . in torsion . . . under compressive loads. Republic ELECTRUNITE® Steel Mechanical Tubing, the original electric resistance welded tube is well known for quality and performance. It's available in carbon and stainless steel in a wide variety of sizes, shapes and gages. Send coupon for more facts.

**HIGH STRENGTH AND LIGHTWEIGHT ADVANTAGES** of Republic Titanium are adding range, speed and maneuverability to both military and commercial aircraft. In the Navy's HOK-1, sections fabricated from Republic Titanium, Type RS-70 Annealed are used as the firewall between pilot and engine compartments. But, titanium should not be looked upon as strictly an aircraft or military metal. Its extremely high resistance to most forms of corrosion makes it attractive for use in processing and chemical equipment, heat exchangers, dehydration trays, anodizing racks, etc. Mail coupon for more information.

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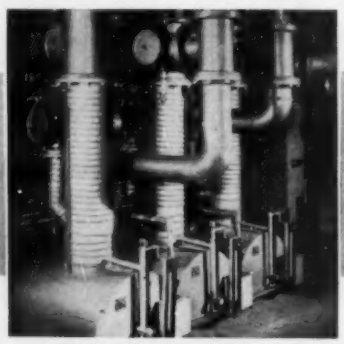
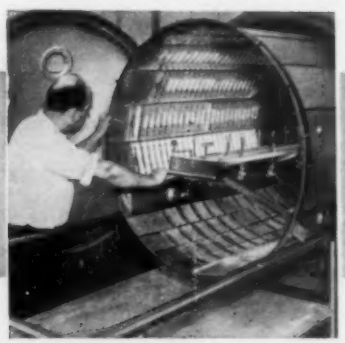
**Compact, self-contained Stokes Vacuum Furnace is being used for investigations of vacuum melting of high temperature alloys, at International Nickel Company, Inc., Bayonne, New Jersey.**

THE METALS INDUSTRY IS PROFITING FROM THE USE OF OTHER STOKES PRODUCTION EQUIPMENT



**Vacuum Pumps.** For rapid evacuation and holding high vacuums, Stokes offers mechanical pumps, and "Ring-Jet" oil vapor diffusion and booster pumps. New design affords 10 to 100% greater speeds.



**Vacuum Metallizers.** Stokes offers a complete line of vacuum metallizing equipment to plate metals for improved surface finish . . . also to provide conductive coatings on non-conductive materials.

# International Nickel studies "super" alloys—melted and cast in Stokes Vacuum Furnace

**The "thermal barrier" may be pushed even higher, for jet engine service, as the result of investigations in vacuum processing of alloys in a Stokes furnace, at International Nickel's Research Laboratory.**

Exclude air and remove gases from metals, and you can create extra properties of strength and endurance that are unattainable by conventional techniques. This is one of the promising lines of metallurgical development that International Nickel Company, Inc. is investigating in their laboratories at Bayonne, New Jersey.

Using a Stokes Vacuum Furnace, the company is studying the effects of vacuum melting and casting on a variety of nickel base alloys such as Inco 700 and 713, destined for jet engines and other extreme temperature service. They also plan to examine the possibilities of vacuum melting of special nickel alloys containing oxidizable elements, stainless steels, cast iron and copper base alloys.

An induction heating crucible, inside the Stokes furnace, handles charges up to 50 pounds. By means of the Stokes vacuum lock, Inco technicians can manipulate the melt during heating . . . even take melt samples while high vacuum is constantly maintained.

Pioneer and leader in high vacuum technology, Stokes offers a comprehensive line of vacuum furnaces which are implementing progress in vacuum metallurgy. Equipment ranges in capacity from laboratory scale furnaces to those capable of melting and casting charges of 3000 pounds on a production basis. The combination of Stokes high capacity Microvac mechanical pumps and "Ring-Jet" Oil-Vapor Booster Pumps gives fast pump-down and dependable maintenance of required vacuum down to the low micron ranges.

Write to Stokes for technical literature, and for a consultation by one of our vacuum specialists on the particular type of vacuum furnace equipment that we can engineer for your specific requirements.

**Powder Metal Presses.** Cost savings and the compacting of incompatible alloys have made powder metallurgy an accepted process. Stokes offers the most complete line of presses in the industry.

**REFERENCE DATA:** Vacuum Furnaces—Catalog 790 • Microvac Pumps—Catalog 752 • Diffusion and Booster Pumps—Specification and Performance Data • Story of the Ring-Jet Pump—Booklet 756 • How to Care for Your Vacuum Pump—Booklet 755 • Vacuum Metallizing—Catalog 780 • Vacuum Calculator Slide Rule • Powder Metallurgy Today • Powder Metal Presses—Catalog 815

*Vacuum Furnace Division*
F. J. STOKES CORPORATION
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# U.S.I. CHEMICAL NEWS

A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries

## *Greenleaf to Handle Market Development of Zirconium And Titanium for U.S.I.*

William C. Greenleaf has been named Manager of Metals Development for U.S.I. and will be responsible for market development and sales of zirconium and titanium sponge, to be produced from U.S.I.'s two new plants now being built in Ashtabula, Ohio.

A recognized authority in the field of zirconium and titanium, Mr. Greenleaf presented three papers during the 1955 Atomic Industrial Forum Zirconium Program, describing (1) melting of zirconium, (2) fabrication of zirconium, and (3) zirconium mill products and prices. He also conceived and developed processes now in general use for producing both wide-sheet and flat-bar titanium and zirconium by continuous strip-mill techniques.

## Faye Named Manager of Sodium Product Sales

Martin Faye has been named Manager of Sodium Product Sales for U.S.I. and will be responsible for coordinating sales and sales promotional activities for metallic sodium, "U.S.I. Isosebacic" acid and related products.

Mr. Faye joined the U.S.I.-National Distillers organization in 1952 in the Market Research and Development Department.

### TECHNICAL DEVELOPMENTS

*Information about manufacturers of these items may be obtained by writing the Editor, U.S.I. Chemical News.*

**A zirconium-copper alloy** now available is reported to combine high electrical conductivity with good strength retention at elevated temperatures. Suggested for electrical motor commutators serving above 500°F where strength is needed. Conductivity is 95.8% of copper. **No.1193**

**Titanium wire cloth** is now on the market in sizes from 60 mesh to coarser grades. It is reported to be particularly suitable for filtering or screening highly corrosive materials. **No. 1197**

# Zirconium and Titanium Lick Roughest Corrosion Problems

### Metals to be Available at Lower Cost in Future; Provide Long-Lived Materials of Construction; Complement Each Other on Corrosion Resistance

It is now practical to fabricate equipment which is *corrosion-resistant to almost every substance encountered in industry*, by using either zirconium or titanium metal. Alloys of either metal, or possibly both, may extend the range even further.

Industrial applications of these metals have been hampered by two considerations: availability and price. Zirconium will shortly be produced at a rate sufficient to supply industrial needs, and titanium has been available to industry during the past two years. And it is expected that increased production of these metals during the next few years will result in significant price decreases.

Twelve to thirteen thousand tons of titanium were available in 1956 and present construction schedules indicate that the figure will rise substantially in 1957. U.S.I.'s new plant alone will add 5,000 tons to the annual production capacity by the end of the year. Zirconium will be on the market in quantity by mid-1957. When its new plant at Ashtabula, Ohio gets under way, U.S.I. will be able to supply 500,000 pounds or more per year to commercial users in addition to its Atomic Energy Commission commitments of 1,000,000 pounds per year.

#### New Metals Economical

Chemical process equipment can now be fabricated from titanium for a little over twice the price of stainless steel, and it is expected that in the future titanium equipment will be only 50-75% higher than stainless. Commercial grade zirconium equipment will probably be priced only 75-100% higher than stainless when volume production is reached.

### Typical Corrosion Resistances* of Zirconium and Titanium

| Corrosive Media | Metal Resistance | |
|---|---|---|
| | Zirconium | Titanium |
| Sulfuric Acid | excellent to good below 80% | good below 5% |
| Nitric Acid | excellent | excellent |
| Hydrochloric Acid | excellent | good below 10% |
| Phosphoric Acid | excellent to fair below 85% | poor |
| Chromic Acid | excellent | excellent to good |
| Aqua Regia | poor | excellent |
| Wet Chlorine Gas | poor | excellent |
| Chlorine Water | excellent | excellent |
| Sodium Hydroxide | good below 90% | good below 50% |
| Ferric Chloride | poor | excellent |
| Calcium Chloride | excellent | excellent |
| Cupric Chloride | poor | excellent |
| Sodium Chloride | excellent | excellent |
| Ammonium Chloride | excellent | excellent |
| Aluminum Chloride | excellent | excellent to fair |

*Above data do not cover all conditions because of space limitations. Literature references may be obtained by writing the Editor, U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.

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*Tear this chart out and preserve it*

# YOUR GUIDE TO COLUMBIA DIE AND SHOCK STEEL GRADES

| TYPE AND GRADES | DESCRIPTION | HARDENING RANGE | QUENCH | TEMPERING RANGE | USEFUL HARDNESS |
|---|---|---|---|---|---|
| **D3 — SUPERDIE** | High carbon, high chromium, high production, oil hardening type with maximum resistance to abrasion for highest production | 1700° F. to 1750° F. | Oil or Salt Bath | 400° F. to 1000° F. | 65/55 Rc |
| **D2 — ATMODIE**<br>**D2S — ATMODIE SMOOTHCUT** | Air hardening, high carbon, high chromium, non-deforming heavy duty long run die steel with better toughness — also available with smoothcutting additives | 1800° F. to 1850° F. | Air | 400° F. to 600° F. | 62/58 Rc |
| **A2S — E-Z-DIE SMOOTHCUT** | Air hardening 5% chromium, deep hardening die steel with smoothcutting additives for maximum economy | 1750° F. to 1825° F. | Air | 400° F. to 600° F. | 62/58 Rc |
| **01 — EXL-DIE** | Standard manganese chromium tungsten non-deforming oil hardening die steel for guages, plastic molds, jigs and fixtures | 1450° F. to 1500° F. | Oil | 350° F. to 450° F. | 64/60 Rc |
| **S1 — BUSTER ALLOY** | Tungsten chromium oil hardening shock resisting steel for heavy duty dies and punches for cold and hot work available in .50% carbon for maximum shock resistance, .60% carbon for best cutting edge life | 1650° F. to 1750° F. | Oil | 400° F. to 800° F. | 61/52 Rc |
| **S5 — CEC SMOOTHCUT** | Silicon manganese alloy steel plus smoothcutting additives for heavy punching, shearing and shock applications, also tool shanks | 1550° F. to 1600° F.<br>1600° F. to 1650° F. | Water<br>Oil | 400° F. to 600° F.<br>400° F. to 600° F. | 62/57 Rc<br>62/57 Rc |


COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILLINOIS

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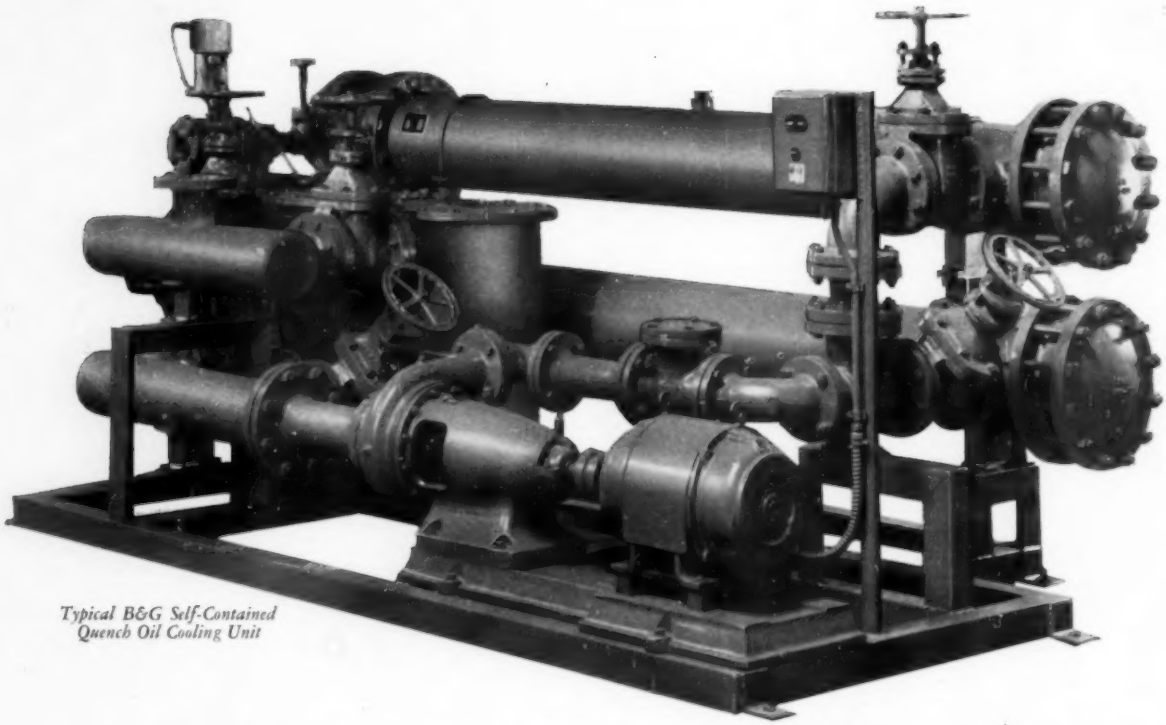
# COLUMBIA TOOL STEELS

HIGH SPEED STEELS: Clarite—Vanite — Acmite — Cobite — Maxite — Molite Smoothcut Molite #3 HOT WORK STEELS: Clarite HW — Formite #3 — Formite #2 — Molite HW10—Vanadium Firedie — Alcodie — Firedie CARBON TOOL STEELS: Columbia Special — Vanadium Extra — Waterdie Extra — Columbia Extra — Columbia Extra Headerdie — Vanadium Standard — Columbia Standard



*Typical B&G Self-Contained Quench Oil Cooling Unit*

**Complete in every detail for**

# *Controlled*

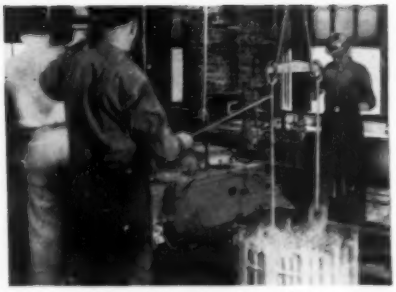
# QUENCH OIL COOLING

Proper control of quench oil temperature is the certain way to maintain uniform quality in heat-treated metals and to avoid excessive sub-standard rejects. The only question is how to provide that control in the most practical, efficient manner.

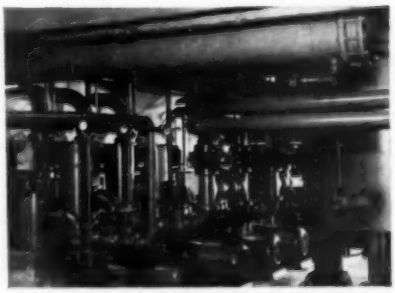
While the individual components of an oil cooling installation can be purchased and assembled on the job, the trend today is to install completely factory-assembled oil cooling systems.

To meet this demand, B&G offers completely self-contained oil cooling units—integrated in every respect—ready for immediate operation. These units are engineered to your specific requirements.

Whether your heat treating volume is large or small, the services of the B&G engineering department are available. Your request for information will receive prompt attention.



*Every piece uniform in quality because uniformly quenched*



*Battery of B&G Quench Oil Coolers*

**B&G QUENCH TANKS**

Properly designed to induce maximum turbulence in the quench oil. B&G Quench Tanks are available in standard models or can be built to meet any specific quenching requirement.

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***Send for this combined Catalog and simplified Selection Manual for B&G Self-Contained Quench Oil Coolers***

B&G

# *Hydro-Flo**

## OIL QUENCHING SYSTEMS

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**Dept. EQ-16, Morton Grove, Illinois**

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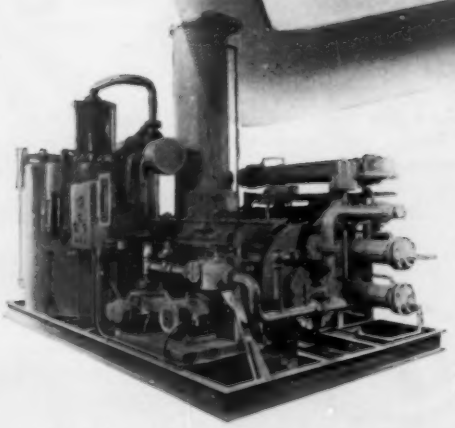
*Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, W. Toronto.*



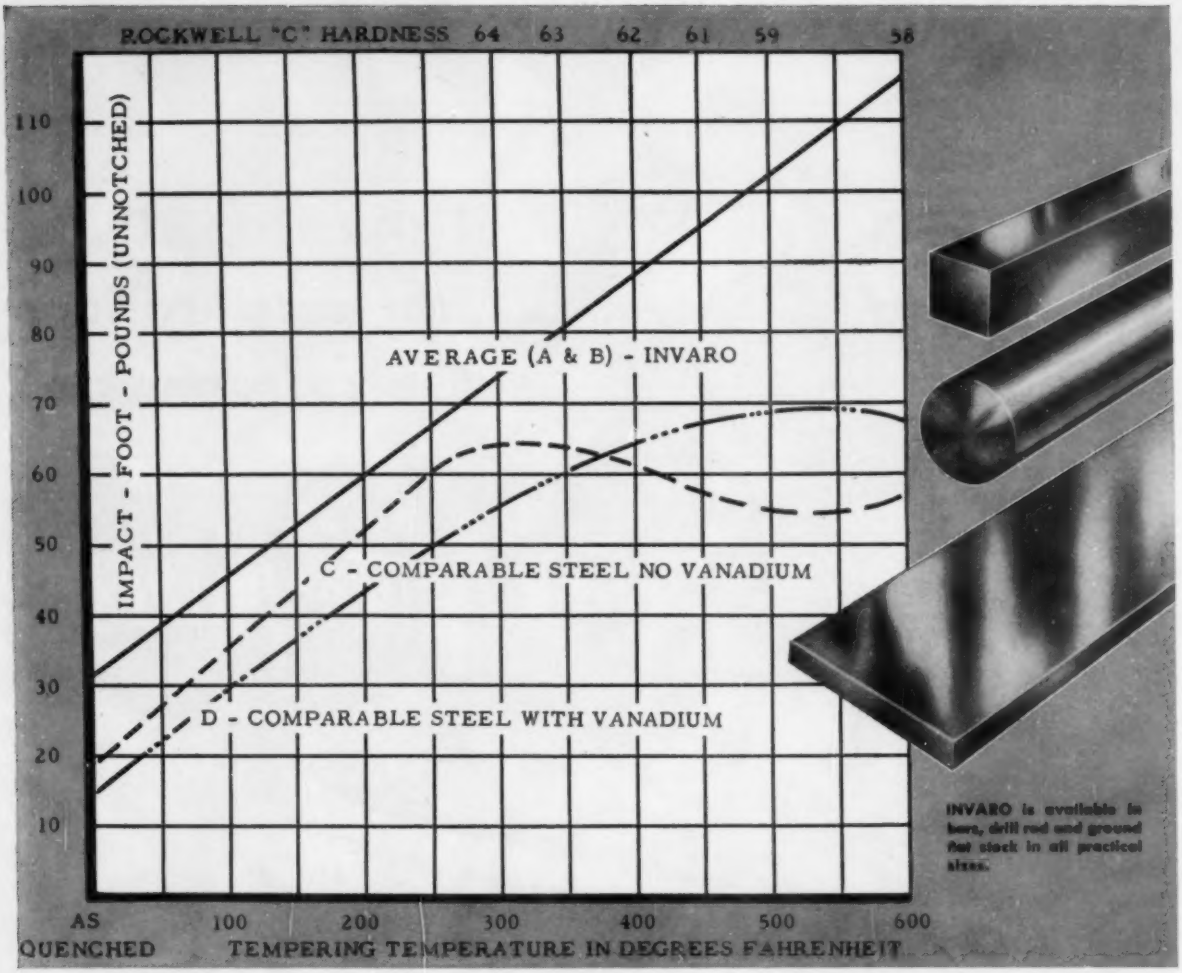
*One of four 12,000 SCFH Nitrogen Generating Systems recently designed and installed at Ford Motor Company's Aircraft Engine Division by Gas Atmospheres.*

THERE can be no doubt that the nation's largest corporations are staffed with specialists who know their business. Men of proved ability to make intelligent decisions. Perhaps that's why *Fortune's* new directory held so much interest for us—for we recognized nine of the first ten leading industrial corporations as Gas Atmospheres customers. In fact, the booklet was fairly studded with names of concerns who are using Gas Atmosphere's Gas Generating Systems for processing foods, petroleum, chemicals, metals, etc.

If you have need for industrial gases in any amounts, why not join the leaders and specify Gas Atmosphere systems.

**gas Atmospheres, inc**

**EQUIPMENT FOR PRODUCING INDUSTRIAL GASES** • 20011 West Lake Rd., Cleveland 16, Ohio




# INVARO . . . *IZOD-PROVED* THE TOUGHEST

## of leading comparable oil-hardening tool and die steels

When the toughness of a tool and die steel is the critical factor of selection, Firth Sterling INVARO is the *toughest* of the tough! That's not just an opinion but a *fact.* Undeniable proof is established by the A.S.T.M. Izod Impact Test, results of which are graphically shown above, comparing steels both with and without vanadium.

INVARO shows a superior toughness in *all* ranges of temperature from a minimum advantage of about 12% to as much as 100% greater! This marked superiority is the result of Firth Sterling's advanced metallurgical practices combined with 67 years of experience in the art of making specialty steels.

Yes, when you want *toughness* in your tools and dies, combined with uniformity, excellent hardening properties and safety in heat treating . . . specify INVARO.

| Chemical Analysis | *All test samples were machined from half-inch annealed bar stock.* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C | Si | Mn | S | P | W | V | Cr |
| Invaro A | .88 | .34 | 1.22 | .010 | .020 | .49 | .19 | .50 |
| Invaro B | .94 | .25 | 1.20 | .014 | .013 | .53 | .22 | .49 |
| Comp. C | .90 | .33 | 1.24 | .011 | .025 | .50 | — | .55 |
| Comp. D | .95 | .34 | 1.27 | .010 | .020 | .50 | .21 | .59 |

**Firth Sterling**

R-320

—INC—

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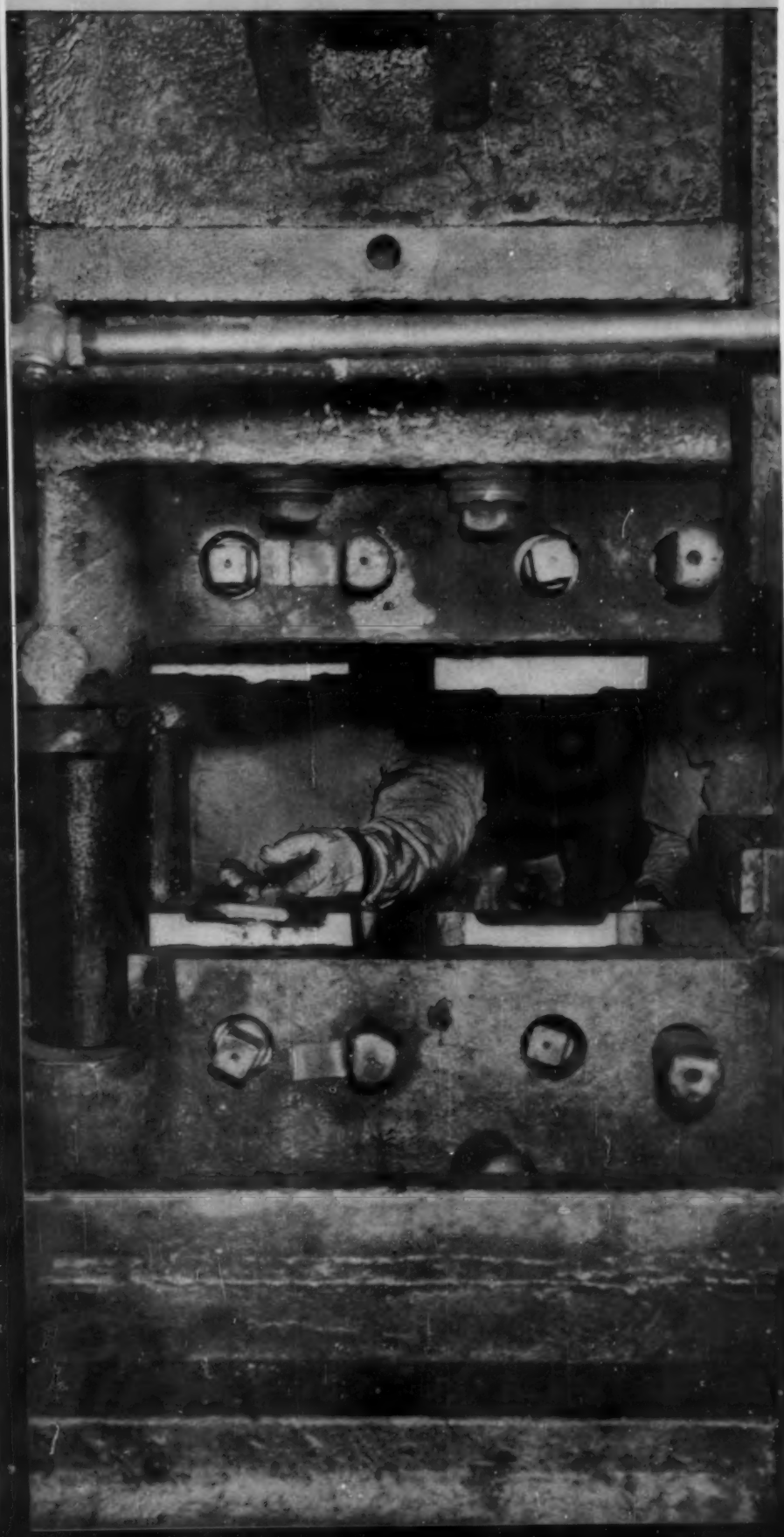
'dag' dispersions . . . *a touch does so much!*



## Colloidal Graphite saves $25,000 a year on jet-blade forging

In the close-limit forging of a jet-turbine blade, a prominent manufacturer found that by using **'dag'** Colloidal Graphite on the dies, only one blow was needed to go from upset billet to final blade shape. Besides eliminating the second hammer-blow previously required, intermediate descaling and reheating operations were also avoided . . . for a total yearly saving of some $25,000 on this single operation.

Both oil-based and water-based **'dag'** Colloidal Graphite dispersions are widely used in forging operations. Diluted and sprayed on the dies, the colloidal graphite forms a slick lubricating film . . . protects the expensive dies and improves metal flow during forging.

Pretreatment of new dies with **'Aquadag'** — colloidal graphite dispersed in water — has paid off handsomely, too. Some firms estimate a 50% greater usable life from forging dies given this protective film of colloidal graphite before being put into service.

The benefits of **'dag'** dispersions for forging and other metalworking applications are discussed in Bulletin 426. Ask for your free copy.

**ACHESON COLLOIDS COMPANY**

**PORT HURON, MICHIGAN**

. . . also Acheson Colloids Ltd., London, England

ACHESON COLLOIDAL DISPERSIONS:

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Mica and other solids.

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**Acheson Colloids Company**
**Port Huron, Michigan, Dept. C-1**

Yes, I want your free bulletin describing **'dag'** Dispersions for Metalworking.

Name_____

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Company_____

Address_____

City_____ State_____

XIX

*This is the nineteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.*

# Determining the Proper Depth of Case in Alloy Steels

In the previous article of this series we discussed the carburizing of alloy steels, pointing out that the purpose of carburizing is to provide a hard, abrasion-resistant outer shell or "case." Such a discussion naturally gives rise to the question, What factors influence the choice of case? Should it be shallow? Medium? Deep or extra-deep?

While it is not always wise to formulate hard-and-fast rules, the following may be used as a general yardstick:

*Shallow cases* (less than 0.02 in.). Suitable where wear-resistance alone is the chief requirement, and where good surface condition after heat-treating is advantageous. Not suitable if high stresses are apt to be encountered in service.

*Medium cases* (0.02 to 0.04 in.). For high wear-resistance. Will stand up under substantial service loads and stresses. The thickness is sufficient to permit certain finishing operations, such as light grinding.

*Medium-to-deep cases* (0.04 to 0.06 in.). For high wear-resistance. A case in this depth range is essential where continuing friction is involved, especially friction of an abrasive or semi-abrasive nature. It is also a good precautionary measure where application of the finished part may sometimes involve crushing action.

*Extra-deep cases* (more than 0.06 in.). Cases of this depth can be obtained by extending the furnace time in pack carburizing. Highly wear-resistant, they also withstand shock and impact. A large camshaft of an internal-combustion engine is a good example of a part requiring the extra-deep case. This is of course particularly true of the cam lobes themselves.

If you require specific advice concerning case-hardened parts, by all means communicate with our Metallurgical Division. Bethlehem technicians are always on call, and you can depend on their recommendations. And you can depend on Bethlehem, too, when seeking new supplies of alloy steels; for Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

*If you would like reprints of this series of advertisements from No. I through No. XVI please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa. The first 16 subjects in the series are now available in a handy 32-page booklet, and we shall be glad to send you a free copy.*

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BETHLEHEM STEEL

**BETHLEHEM STEEL**

*HARROP*

# ELECTRIC FURNACES

equipped to YOUR needs
increase laboratory and
production efficiency

**NMR-10-SP NON-METALLIC RESISTOR FURNACE**
Firing chamber 10"x10"x11", silicon carbide resistor heating elements. Maximum firing 2800°F. Illustrated with temperature indicator and program controller . . . size and instrumentation may be varied to meet requirements.

Solve your particular high temperature firing problems in metallurgical research, testing or small scale production with a versatile Harrop non-metallic resistor furnace.

Solve your lower temperature firing problems with one of Harrop's complete line of metallic resistor furnaces.

For special applications demanding an unusual firing chamber, door opening and temperature range, Harrop will design and build a furnace to meet your specific need . . . whatever it may be.

You'll profit by Harrop's years of experience in designing and building full temperature range of furnaces and kilns for both research and production. This engineering know-how is responsible for the sound scientific design . . . modern appearance . . . easy operation . . . long, economical service you get with every Harrop furnace.

**NMR-7 NON-METALLIC RESISTOR FURNACE**
Compact unit with furnace and controls in single cabinet. Firing chamber 7" x 7" x 9", drop door, temperature controller. Adaptable to other instrumentation.

***Get a non-obligating analysis*** and recommendation of your furnace requirements. Send full particulars as to your materials . . . temperature range . . . heat control . . . and firing objectives. Address inquiry to:

**Dr. Robert A. Schoenlaub**
TECHNICAL ADVISER
**HARROP ELECTRIC FURNACE DIVISION**
OF
**Harrop**
CERAMIC SERVICE COMPANY
3470 E. Fifth Ave.
Columbus 19, Ohio



STROMAN PRESENTS

# Comocast

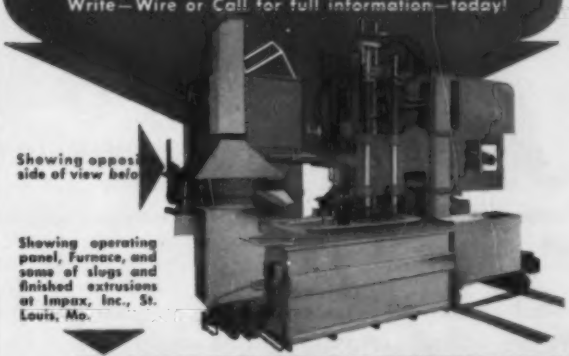
**The One and Only Slug Casting Machine for Aluminum Forging and Aluminum Impact Extruders!**

Here is Stroman's newest invention that casts slugs from ingot in one complete operation, making it possible to produce perfect slugs ready for forging or extrusion, at a speed heretofore thought impossible. Some sizes produced as many as 1500 pieces an hour . . . and a die can be constructed to fit your specific needs.

Operation is completely automatic, operation is simple, and it saves a tremendous amount of man-hours in production. It is foolproof, producing perfect slugs every time, for forging or extruding, with no return scrap metal.

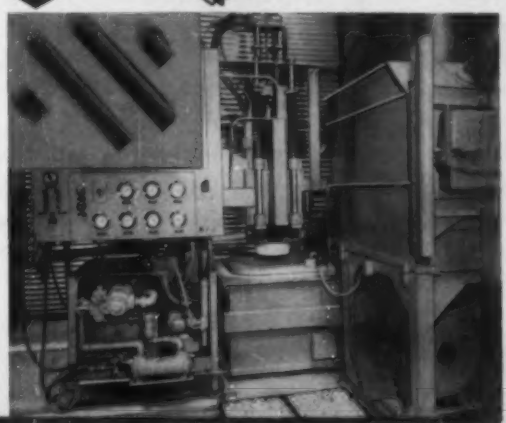
Let us show you this COMOCAST in operation, show you its efficiency and mechanical perfection of each slug . . . even make some slugs to fit your production. Yes to try. Honest, it's the finest metal-serving machine you forgers or extruders have ever had presented to you.

Write—Wire or Call for full information—today!



Showing opposite side of view below

Showing operating panel, Furnace, and some of slugs and finished extrusions at Impax, Inc., St. Louis, Mo.



**STROMAN** FURNACE AND ENGINEERING CO.
Franklin Park, Illinois

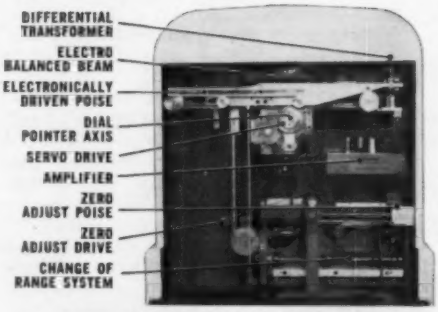
# NOW... two more reasons for retiring inadequate testing machines

1. NEW SENSITIVITY
2. RAPID RESPONSE

Here are the *sensitivity* and *rapid response* plus complete instrumentation you need for testing at elevated temperatures as well as at room temperatures.

With Riehle's new Electro-Balanced Indicating Unit, you know you are actually conforming with modern, more rigid testing requirements. No longer need you go on testing superficially with inadequate machines that just weren't intended for modern test procedures.

Riehle's new sensitivity and rapid response assure you of that flexibility and precision you must now have. The new Electro-Balanced Indicating Unit is available for both hydraulic and screw power testing machines — by Riehle.




**SLIGHT MOTION AT BEAM END PROVIDES SUFFICIENT SIGNAL TO OPERATE THE SERVO MOTOR . . . AND MOVE THE POISE TO ESTABLISH FORCE EQUILIBRIUM.**

**NEW BULLETIN . . . MAIL COUPON**

Riehle TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

**RIEHLE TESTING MACHINES**
**Division of American Machine and Metals, Inc.**
**Dept. MP-157, East Moline, Illinois**

Please send your free 4-page Bulletin RU-14-56 with full data on the new Riehle Electro-Balanced Indicating Unit.

COMPANY

ADDRESS

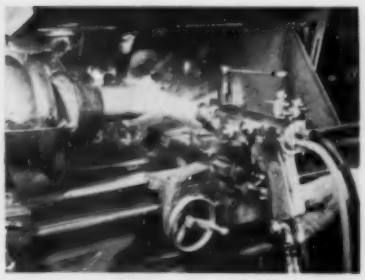
CITY ZONE STATE

ATTENTION MR.

# APPLICATION and EQUIPMENT new products

### *Hardfacing*

A new metal spray unit for applying hardfacing alloys and others metals in powder form has been announced by Wall Colmonoy Corp. The new sprayer may be used in applying hardfacings to most types of steel (including stainless), cast iron and copper

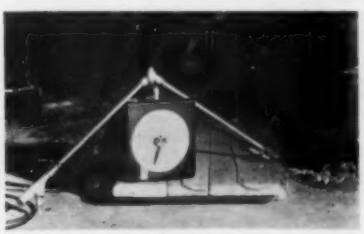


parts by a process in which the powdered alloys are first applied by spraying and then are fusion-bonded to the part by heating with an oxy-acetylene flame. Metal spraying operations using aluminum, zinc, copper, nickel, stainless steel, brass, lead or high temperature brazing alloys in powder form can also be handled by the new unit.

**For further information circle No. 1 on literature request card, page 48-B.**

### *Molten Metal Temperatures*

A new measuring system for checking the temperatures of molten metals up to 3200° F. has been announced by Leeds & Northrup. The system employs a lightweight immersion thermocouple in combination with a portable electronic indicator or permanently mounted recorder. It may be used to determine the exact freezing point of a new melt, to indicate when the melt in a furnace reaches the established pouring temperature and to check temperatures of melts at various locations in the shop, such as in transfer ladles, shank ladles, cupola troughs, runner boxes and risers.



**For further information circle No. 2 on literature request card, page 48-B.**

### *Hafnium Extraction*

U.S. Industrial Chemicals Co. has taken an exclusive option on a process for separating hafnium from zirconium chloride which was developed by the Commonwealth Scientific and Industrial Research Organization of Australia. Hafnium renders zirconium metal unsatisfactory for use in certain types of atomic reactor construction. The Australian process reduces the cost of separating hafnium from zirconium by eliminating the chemical extraction step in current and projected commercial production. The U.S. Industrial Chemicals Co. expects to complete by July 1957 its 2,000,000-lb.-per-yr. plant which will produce reactor grade zirconium sponge. Initially this plant will use the conventional separation method but this will be superseded by the new method when demonstrated.

**For further information circle No. 3 on literature request card, page 48-B.**

### *Metal Finishing*

The Mitchell-Bradford Chemical Co. has announced two new products for the metal finishing industry, an alkaline deruster #2 and emulsion cleaner #26. The alkaline deruster is a salt mixture to be dissolved in water and used non-electrolytically at 180° F. to boiling. It will also remove many types of paint. It will not cause hydrogen embrittlement, will not attack the base metal and is non-toxic. The emulsion cleaner is an organic cleaner for removal of heavy oils, greases and soils. It can be used at 1 part cleaner #26 to 7 or more parts kerosene or safety solvent at room temperature.

**For further information circle No. 4 on literature request card, page 48-B.**

### *Shell Core Blower*

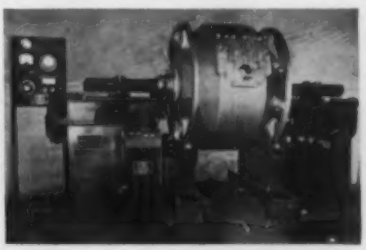
The Harrison Machine Co. has announced a dual station fully automatic hollow core blow and dump machine featuring a swinging head. The sand feed arrangement delivers sand from the main bin to self-feeder

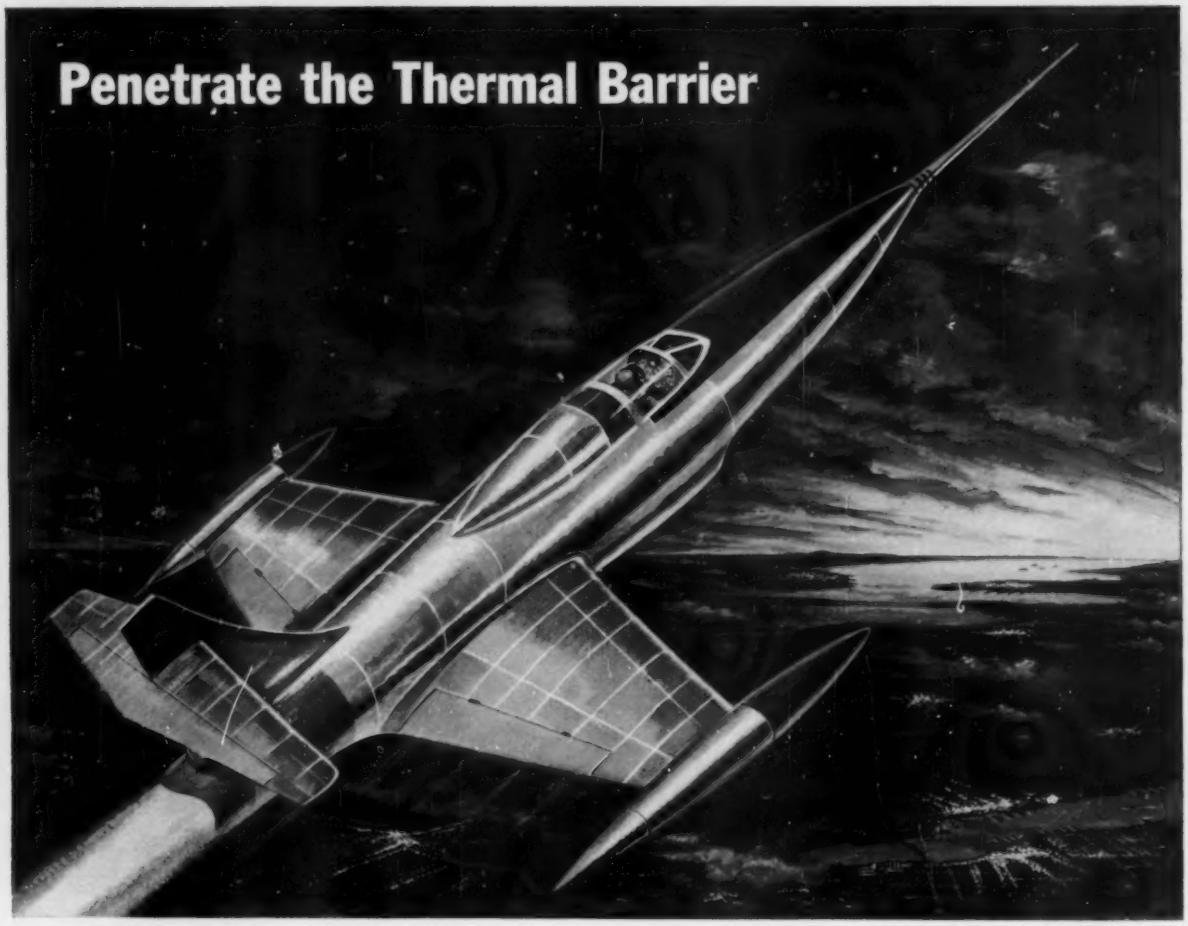
hopper and transfers sand to tube between blowing cycles. Thus, one side is curing cores while the other is blowing cores. Electrically controlled heater units assure the wall thickness desired. (450° F. will cure a 1/16 in. shell in 15 sec.)

**For further information circle No. 5 on literature request card, page 48-B.**

### *Electric Furnaces*

A new series of indirect arc furnaces has been announced by Detroit Electric Furnace Div. The furnaces are pedestal mounted, with a new arc control system and motor driven electrodes. The arc control is of the






# *MicroMach extra-high-tensile stainless steel sheets up to 48" WIDE for aircraft and missile use*

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

*For further information write to Aircraft Steels Dept.*

**Washington Steel** *Corporation*
I-T WOODLAND AVENUE
WASHINGTON, PA.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36" wide can be had as thin as .005", and over 36" to 48" wide as thin as .010" in all commercial finishes and tempers.

magnetic amplifier type and permits variation in the speed of the control motor so that its speed is directly proportioned to unbalance. Motor-driven electrodes are automatically controlled and also may be moved by manual push-button controls while recharging or for electrode positioning. Furnace capacities are from 350 to 4000 lb.; k.w. ratings from 125 to 600.

**For further information circle No. 6 on literature request card, page 48-B.**

### *Laboratory Equipment*

A new vacuum heating stage designed for the study of the microstructure of metals at temperatures

up to 1100° C. has been announced by Unitron Instrument Div. A special 40× objective with an extra-long working distance of 5.8 mm. is available so that observations and photographs may be made at magnifications as high as 800×. After any given temperature has been attained, argon gas may be introduced as a quench and the resulting structural changes in the metal observed. The vacuum heating stage may be used with any metallurgical microscope of the inverted type.

**For further information circle No. 7 on literature request card, page 48-B.**

### *Temperature Control*

A new multi-point pyrometer controller has been announced by Thermo Electric Co. It permits automatic temperature control of 4 to 10 separate units with one instrument. This multi-point controller applies to almost any installation suitable for two-position control action, including creep test machines, multi-zone ovens and furnaces, laboratory aging and reaction vessels, batteries of batch process units and others. In operation a pulse timer and selector-switch automatically connect thermocouples in sequence to the master control unit which compares each thermocouple voltage to its set point, and energizes or deenergizes the corresponding load relay to the process unit. The controllers can be set to skip one or more points providing optional control of a


THE MARK OF QUALITY

BARBER COLMAN

Wheelco Instruments

**Control, record temperatures *exactly*, with Series 8000 Recorder**

Batteries of Wheelco instruments serve every industry for precision control at low cost.

Recording of process temperatures is frequently as important as exact control, in many phases of metalworking. For example, an accurate record of temperatures when heating bar stock for forging will show variations that could cause rejects. New Wheelco Series 8000 Potentiometer-Recorder will *control* and *record* variables such as temperature, strain, speed, hydrogen ion (pH) and other factors which can be resolved into electrical signals. Write *today* for Bulletin F-7747 for the complete story of this versatile Wheelco instrument.

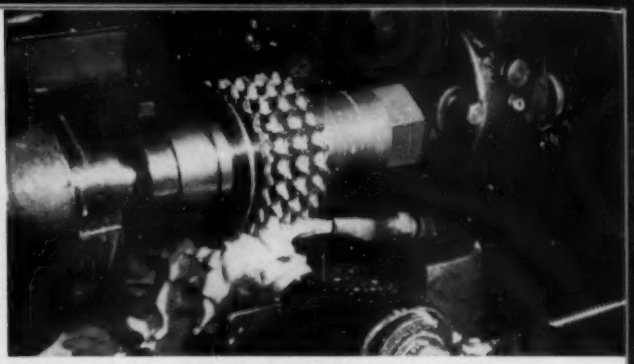
**Barber-Colman Company**

DEPT. M, 1518 ROCK STREET, ROCKFORD, ILLINOIS

BARBER-COLMAN of CANADA, Ltd., Dept. I, Toronto and Montreal, Canada

Industrial Instruments • Automatic Controls • Air Distribution Products
Aircraft Controls • Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

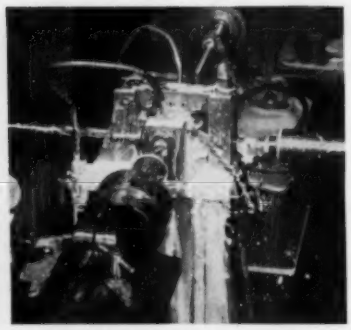
**TURNING AND DRILLING.** During the machining of a 9-in. piece using carbide-tipped tools, S.E.C.O. removes heat fast ...assures long runs, top speeds.



**HOBBING.** Flooding the cutting edges of a high-speed-steel hob working 1117 steel, S.E.C.O. provides lubricity and cooling power needed for long tool life.

**CENTERLESS GRINDING.** In grinding 4320 H steel pins, S.E.C.O. keeps wheels clean. Grinding dirt drops out quickly...is not recirculated. Parts are rust-protected.

# SUNOCO EMULSIFYING CUTTING OIL HANDLES 4 TOUGH JOBS...EASILY



**DRILLING AND REAMING.** On steel forgings with a 350/400 Brinell, S.E.C.O. keeps drills cool...gives clean cutting.

Whether you are shaping, hobbing, grinding, reaming, boring or milling, it will pay you to look into the advantages of SUNOCO EMULSIFYING CUTTING OIL.

Moderately priced, S.E.C.O. has been industry's most widely used soluble cutting oil for years. Higher-than-ever machining efficiency, increased detergency, easier mixing, and other added advantages are helping keep S.E.C.O. the leading emulsifying cutting oil in the country today.

For complete information about S.E.C.O. see your Sun representative. Address SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-1.

**INDUSTRIAL PRODUCTS DEPARTMENT**

## SUN OIL COMPANY

**Philadelphia 3, Pa.**

**IN CANADA: SUN OIL COMPANY, LIMITED, TORONTO AND MONTREAL**

SUNOCO

minimum of four and a maximum of ten units. Usual operating speed is 3 sec. per point, 30 sec. for all 10 points.

**For further information circle No. 8 on literature request card, page 48-B.**

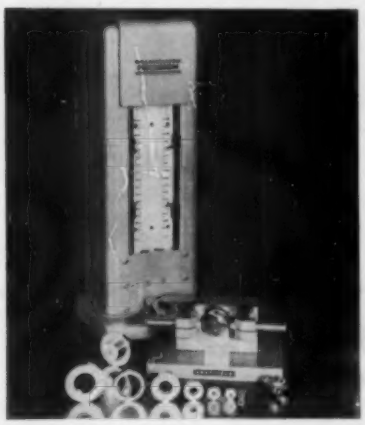
### *Corrosion Protection*

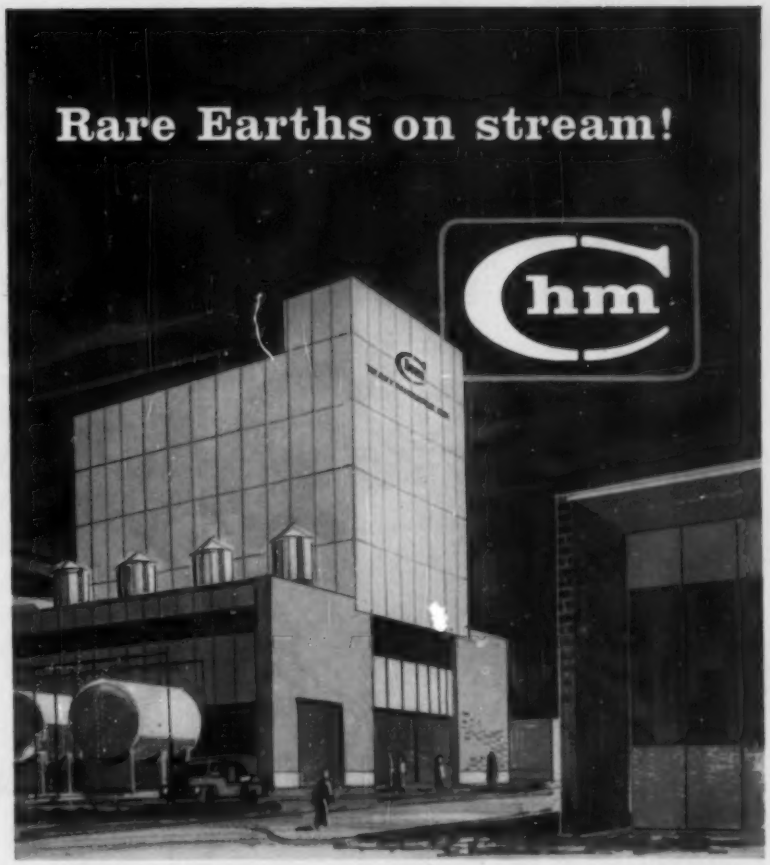
Selinizing Process Co. has announced a coating of a silicone resin dispersion in an organic solvent which offers high corrosion resistance. The fluid is sprayed on, allowed to air dry, then baked for 1 hr. at 480° F. The protective coating resulting from this treatment is 0.0002 in. thick and has shown no loss of adhesion and no attack on the underlying metal during a 2000 hr. salt spray test. This fluid is already in use as a chemical release agent.

**For further information circle No. 9 on literature request card, page 48-B.**

### *Gage*

The Sheffield Corp. has announced a pneumatic gage designed primarily for inspecting bearing assemblies, but which can be used on other applications where an adjustable i.d. and o.d. check is desired. Interchangeable spindles and backstops are used for different bore sizes while the outside diameter check is adjustable through the 2 in. size range. This gage is supplied with 14 sets of tooling, each set consisting of a different size




**Rare Earths** have remained rare only because of the exceptional technology required to process them. The best of this technology is everywhere evident in HEAVY MINERALS CO.'s shining new Chattanooga plant, now on stream.

Using domestic ores from its own mines, HEAVY MINERALS produces the highest purity rare earths for American industry.

Purified rare earths give new and exciting qualities to metals, glass, ceramics and illuminating materials. Their use is spreading to atomic energy and chemistry — in fact the rare earths constitute a new industrial frontier.

HEAVY MINERALS supports its processing operations with a vigorous research program. Its research and development personnel welcomes the chance to share its technology with rare earth users and potential users.

*Send for free informative booklet*

**HEAVY MINERALS CO.**

**RARE EARTH CHEMICALS • THORIUM • HEAVY MINERALS**

4000 NORTH HAWTHORNE STREET, CHATTANOOGA 8, TENN.
*SALES OFFICE:* 261 MADISON AVENUE, NEW YORK 16, N. Y.

# TRADE-MARKS WHICH IDENTIFY THE ORIGINAL AND THE BEST

"PHOSPHOR BRONZE."®

*Phosphor Bronze* ®

ELEPHANT BRAND®

A little more than seventy-five years ago a wonderful new kind of copper and tin alloy possessing high tensile strength, great resiliency and unusual corrosion-resistant properties was introduced to American industry. This new bronze alloy had been perfected by the addition of a small amount of phosphorus to the copper and tin mixture.

No other producer of metals in the United States was able to duplicate this extraordinarily useful alloy. Therefore, because of the uniqueness of this new phosphorus-bearing *alloy*, the smelters responsible for its creation gave it a trade name "PHOSPHOR BRONZE" and adopted for itself the firm name of The Phosphor Bronze Smelting Company.

This was the first Phosphor Bronze ever produced in the United States of America.

"Phosphor Bronze" was immediately accepted by America's burgeoning industry. Demand for the new alloy grew by leaps and bounds and The Phosphor Bronze Smelting Company soon had many imitations of its products. So, to protect customers from spurious imitations, the trade name of "Phosphor Bronze" was incorporated into two distinctive *trade-marks* which were duly registered in the U. S. Patent Office on February 21, 1888. These trade-mark registrations have been maintained, in full force, throughout the intervening years and are presently owned by The Phosphor Bronze Corporation, successors to the original Phosphor Bronze Smelting Company.

In time, new variations of the original "Phosphor Bronze" alloy were introduced by the now-famous smelting Company. To identify these, the trade name of "ELEPHANT BRAND" was adopted, together with a distinctive picture of an elephant. The words "ELEPHANT BRAND" were incorporated into a *trade-mark* and registered with the U. S. Patent Office on August 20, 1907. The picture of the elephant shown in this advertisement, is a new one, designed to supersede its 1906 predecessor and was Registered, as a *trade-mark,* on October 2, 1956.

We are proud that American industry has wholeheartedly accepted our product. The name "PHOSPHOR BRONZE" has become internationally known and is familiar to metalworking men and metallurgists everywhere.

In view of this unanimous acceptance and usage, we—the officers, stockholders and employees of The Phosphor Bronze Corporation acknowledge the universal use of the name and herewith bequeath it to the American metalworking industries. We reserve only . . . the exclusive right to use the trademarks illustrated above.

---

**THE PHOSPHOR BRONZE CORPORATION**

*A Wholly Owned and Operated Subsidiary of The Seymour Manufacturing Company*

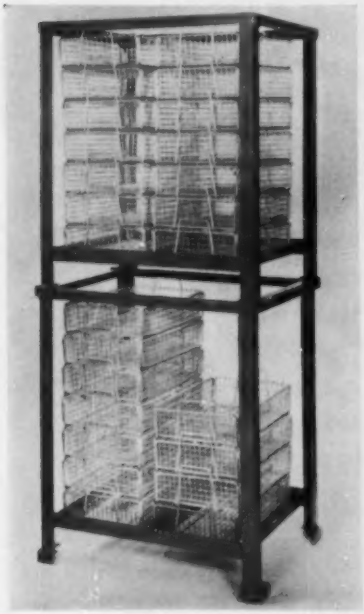
**SEYMOUR, CONNECTICUT**

spindle and corresponding minimum and maximum setting rings.

**For further information circle No. 10 on literature request card, page 48-B.**

### *Wire-Basket Racks*

A new rack designed for fork truck handling and stacking of wire baskets has been announced by Jaxon Wire Products. The rack is of extra heavy angle iron construction. It is arc welded and has stacking legs that



provide adequate room for fork clearance. The racks can be stacked on one another. The standard unit is 36 by 32 by 28 in.

**For further information circle No. 11 on literature request card, page 48-B.**

### *Gas Purifying*

Development of a new gas purifying and drying unit incorporating catalytic purifying with reactivating-type dryers has been announced by Baker & Co. The new unit employs a Linde molecular sieve in place of previously used activated alumina to register gas dew point readings of better than −100° F. In a typical application, the Deoxo Puridryer feeds dry oxygen-free hydrogen into an atmospheric furnace at a maximum rate of 100 cu. ft. per hr. Capacity is dependent upon the moisture content and the impurity of the incoming gas.

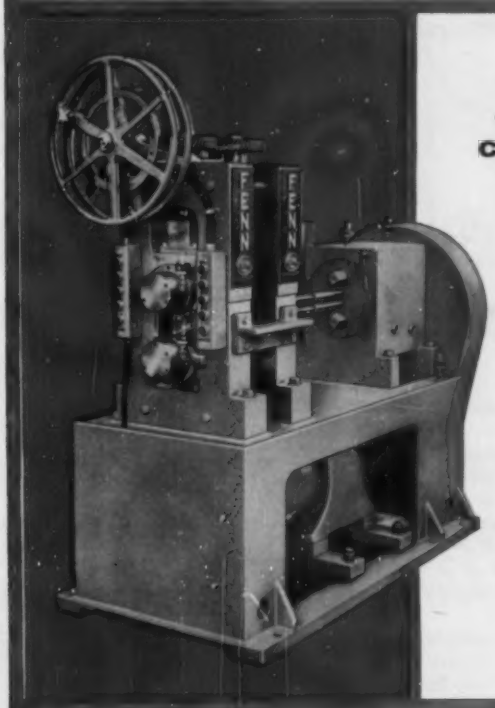
**For further information circle No. 12 on literature request card, page 48-B.**

### *Measuring Scale*

A new measuring scale available in lengths up to 12 in. and subdivided


VERSATILE LABORATORY SIZE

**ROLLING MILL**



COMBINES

**PRECISION**
**VERSATILITY**
**COMPACTNESS**
**MODERATE COST**

**EXTRA HEAVY**
BEARINGS PERMIT ROLLING NEWEST AND TOUGHEST METALS

**MODEL 4-053** is the newest and finest Precision Rolling Mill engineered especially for metallurgical and research laboratories in industry and colleges . . . or for a production mill in many applications. Extremely flexible it can be used as (1) a two-high, (2) a four-high with work rolls driven, and, (3) a four-high with back-up rolls driven. This unique three-way drive, and a full line of accessories, permit a complete range of reductions in both hot and cold rolling. Write for complete specifications or copy of our rolling mill catalog.

FENN

**FENN ENGINEERING SERVICE**
is available at all times to help you solve rolling problems. Fenn engineers will also gladly test-roll samples of your materials.

Precision Rolling Mills

Turks Heads

Wire Shaping Mills

Swaging Machines

Wire and Tube Drawing Machines

The Fenn Manufacturing Company, 508 Fenn Road, Newington, Connecticut

# *Twice the life of previous heating elements!*

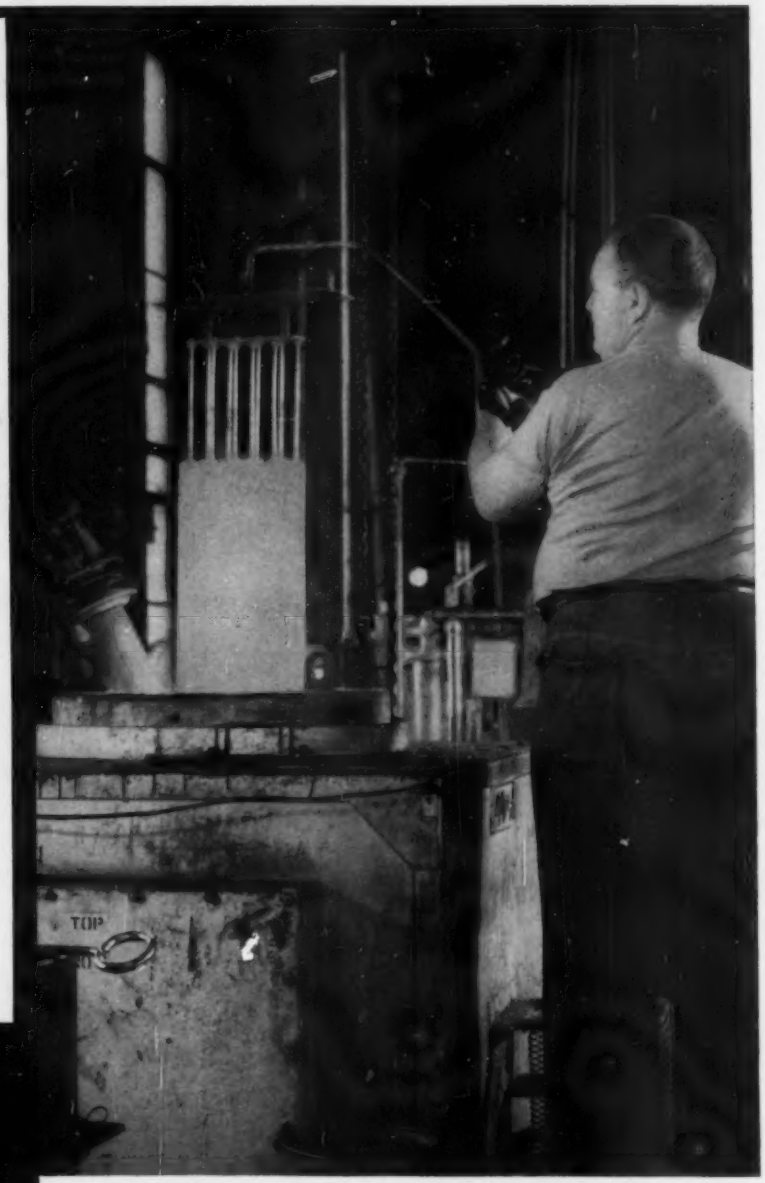
## ...a report on "HOT RODS" in intermittent service

Many plants report Norton "Hot Rods" outlast other non-metallic elements by a considerable margin. Here's a case where they're lasting twice as long — in gruelling intermittent service.

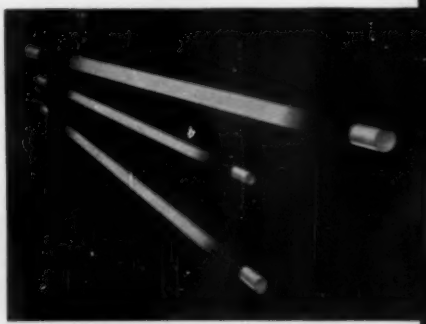
This means big savings in element costs alone. You also save maintenance expense, due to less frequent changing of elements and voltage taps. And you don't have to shut down the furnace to replace elements.

Also, "Hot Rods" heat more uniformly, due to their slow, evenly matched rate of resistance increase. This helps protect product quality and maintain a smooth production flow.

The booklet, *"Norton Heating Elements,"* tells you more about how "Hot Rods" can help improve your furnace operations and cut costs. Write for your copy to NORTON COMPANY, Refractories Division, 320 New Bond Street, Worcester 6, Massachusetts.




***After Hardening At 2200°F,*** white-hot hacksaw blades are lifted from a Lindberg hydrizing furnace in the plant of *G. W. Griffin Co.,* Franklin, N. H. — a well-known manufacturer of hacksaws. Norton CRYSTOLON* heating elements ("Hot Rods") are located in air outside the crucible which contains the protective atmosphere. Heating cycles are intermittent, the furnace being shut down each night. The "Hot Rods" in this installation have averaged twice the service life of the elements used previously.



***CRYSTOLON Heating Elements,*** or "Hot Rods", are a typical Norton Rx — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes and interchangeable with your present rods.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

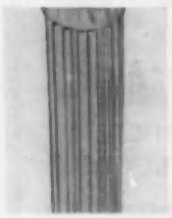
*Making better products... to make your products better*

throughout its length into increments of 0.001 in. has been announced by the Elliott-Myers Corp. The graduations are numbered at every 0.050 in. The scale is viewed through a simple microscope. By using a microscope incorporating a vernier eye piece, the 0.001 in. increments are divided into tenths, making possible direct readings to 0.0001 in.

**For further information circle No. 13 on literature request card, page 48-B.**

### *Chromium Plating*

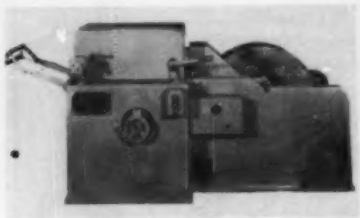
Alpha Metals has announced a "ripple round" lead alloy anode, designed to give platers the maximum in plating surface area. By adding a deep ripple to the conventional round anode, the surface area has been increased by 6.8% without increase in anode size or weight. Anodes are supplied with a choice of six hooks.



**For further information circle No. 14 on literature request card, page 48-B.**

### *Straightening Machines*

A complete line of combination coil cradles and straightening machines for feeding leveled stock to all types of presses has been announced by the Brandes Press Co. They can handle stock weighing up to 15,000 lb. with 6, 7 or 9 rolls provided for straightening. Standard manually controlled variable speed drive with a 4 to 1 reduction permits selection of feed



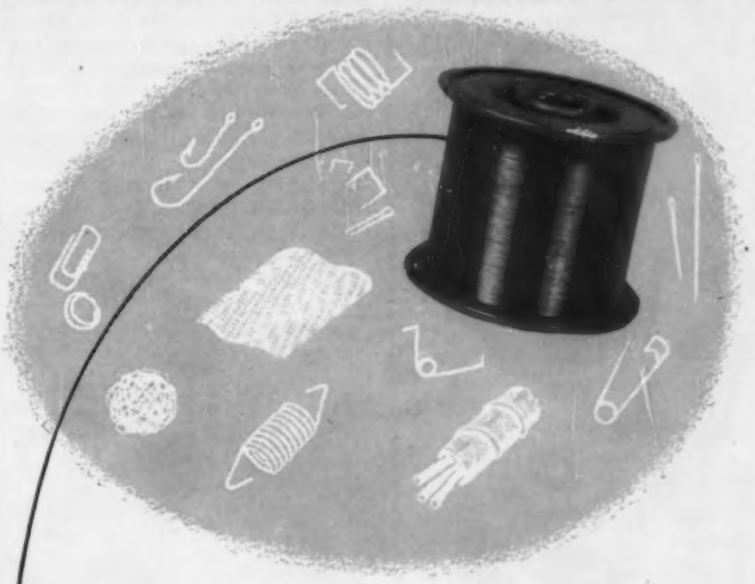
speeds from 30 to 120 ft. per min. Loop control is standard on all Brandes combination coil cradles and straightening machines, reducing to a few feet the distance between cradle and press without interfering with die handling and press service. Power is provided by a variable speed drive which operates continuously, synchronized with the press.

**For further information circle No. 15 on literature request card, page 48-B.**

### *Computing Relay*

A universal pneumatic computing relay which can be adjusted to per-


**FOR FINE WIRE PRODUCTS . . .**



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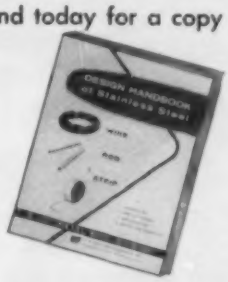


Write to Alloy Metal Wire Division, H. K. Porter Company, Inc., Prospect Park, Pa.

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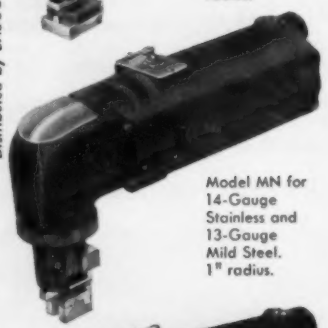
Model HN for 10-Gauge Stainless and 8-Gauge Mild Steel. 6" radius.

Pneumatic Nibbler for 10-Gauge Stainless and Mild Steel. 6" radius.



Model MN for 14-Gauge Stainless and 13-Gauge Mild Steel. 1" radius.

Model LNC for 16-Gauge Corrugated Sheet Metal and Sheet Metal Pipe. 1" radius.

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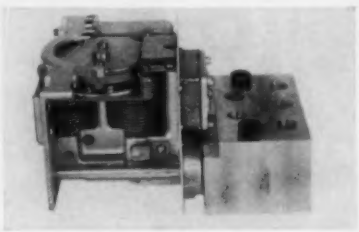
form any one of six different arithmetic functions has been announced by the Foxboro Co. Six other relays are also available, each designed for a specific computing operation. Consisting of a modified Model 58 Consotrol controller with a new type manifold, the series of relays operates on the force balance principle, with four bellows positioning a floating disk about a fulcrum. The disk acts as the flapper of a conventional flapper-nozzle detector. Forces exerted by pressures in the bellows establish



the position of the disk in relation to the nozzle. The resulting pressure change in the feedback bellows maintains the balance position of the disk. The manifold provides external connections to all four bellows so that measurement signals can be received and computed according to the equation desired. The adjustable fulcrum, is used to weigh the various measurements according to their values in the equation. Substitution of springs for certain bellows will change the relay from one computing function to another.

**For further information circle No. 16 on literature request card, page 48-B.**

### *Radiant Tube Burners*

An adaptable new gas burner assembly has been announced by Eclipse Fuel Engineering Co. Five series, ranging in capacity from 250,000 to 625,000 Btu. are available.

Tube sizes vary from 4½ to 8⅝ in. maximum o.d. A choice of mounting, air and gas regulation and ignition features is given. Mounting can be either slip fit or flange type, with the latter adapted to meet the user's tube flange requirements. Regulation of air and gas can be fixed or adjustable.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Three types of ignition are offered—gas pilot, spark, or pilot-spark combination.

**For further information circle No. 17 on literature request card, page 48-B.**

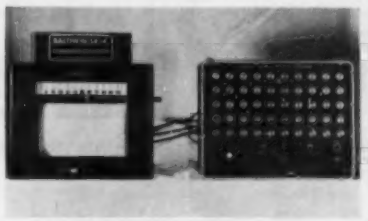
### *Aluminum Etchant*

A newly developed aluminum etchant has been announced by Hanson-Van Winkle-Munning Co. The new 85S is used as a caustic etchant bath. It contains an inhibitor which eliminates formation of scale on tank walls and coils and also provides a means of minimizing formation of sodium aluminate, providing maximum utilization of the caustic soda.

**For further information circle No. 18 on literature request card, page 48-B.**

### *Recorder*

A new 50-point automatic recorder, which plots automatically and in sequence percentage of load versus strain readings from as many as 50 two-or-four-arm strain gage bridges, has been announced by Baldwin-Lima-



Hamilton Corp. It consists of three units. The recorder cabinet, a small cabinet containing controls for zeroing gage factor and range, and a switching and balancing unit. A rotating hand shows the channel in use.

**For further information circle No. 19 on literature request card, page 48-B.**

### *Resistance Thermometers*

West Instrument Corp. has announced a full line of single and multipoint resistance thermometer indicators and controllers. They are being used for low temperature ovens, for taking bearing temperatures, for air conditioning and cold treating. The wheatstone bridge principle is used with a resistance bulb, which varies in resistance according to temperature. A selection of standard and double scale ranges (from –100 to 500° F.) is offered with accuracy to ½% of range.

**For further information circle No. 20 on literature request card, page 48-B.**

### *Hydrogen Embrittlement*

A new "time-and-temperature" paint which will indicate hydrogen embrittlement hazards has been announced by EverLube Corp. It was developed for application to heat treated parts that have been electro-

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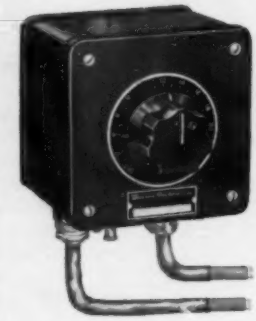

T-E's Rotary Selector Switch provides a fast, convenient means of transferring a number of sensing elements. It permits frequent checking of many thermocouples or resistance bulbs—switching them from one instrument to another—or switching one instrument to many measuring points. It can be used with either millivoltmeter or potentiometer-type pyrometers or with resistance thermometers. This switch has spring-loaded contacts and wipers of the same silver alloy—preventing spurious voltages from thermoelectric action. Stocked in three models with OFF to 6, 12 or 24 points.

*Write for Bulletin 24-100-H.*

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In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

# Announcing . . . "SUPERCASE"

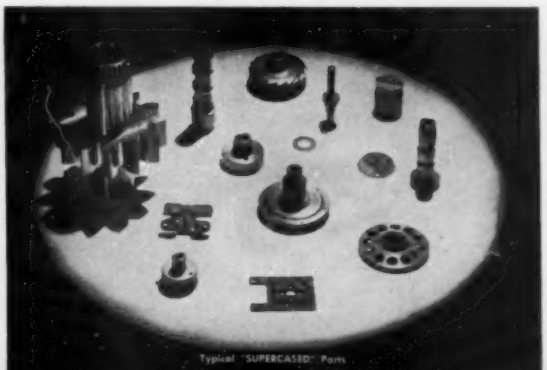
## OUR NEW PROCESS for NITRIDING STAINLESS STEEL

"SUPERCASE" is especially adaptable for use on parts where an extremely hard, wear resistant surface with maximum corrosion resistance is needed.

"SUPERCASE" has already been successfully proven in use by ELECTRONICS, AIRCRAFT, CARBURETOR, TRANSMISSION and SMALL PARTS manufacturers.

### "SUPERCASE" HAS THESE ADVANTAGES OVER OLDER METHODS OF NITRIDING:

1. "SUPERCASE" depths are controlled to closer limits, because a more uniform, extremely hard case is obtained with only a light case required. Normal case depth ranges between .0003 to .0007, yet wear tests on "SUPERCASED" small gears proved they outlasted, by several times, the life of the unit to be used.
2. "SUPERCASE" may be removed in the event of a change after parts have been finished — the parts reworked and then re-nitrided.
3. "SUPERCASING" may be done on a selective basis. To machine an area further after nitriding, area can be masked off and will remain soft after processing.
4. "SUPERCASE" can be used on all types of Stainless Steel.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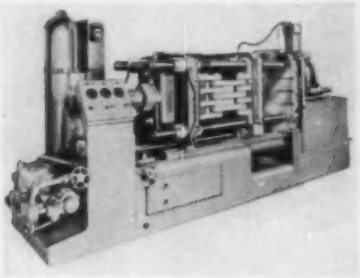
plated, pickled or phosphate treated to permit visible proof that each part has been baked to relieve hydrogen embrittlement. Tempa-Dot appears as a vivid red dot before baking and changes color after the proper bake.
**For further information circle No. 21 on literature request card, page 48-B.**

### *Die Casting Machines*

A new 450-ton capacity die casting machine has been announced by Unit Products Div., Uniloy Corp. Special features of the Unicaster 120 include a self-contained hydraulic system mounted on a sub-base of the



machine, simplified tank clean-out with easily accessible oil filters, a heavy toggle system and large accumulator tank. Electrical controls permit operation of equipment on an automatic cycle or manually.
**For further information circle No. 22 on literature request card, page 48-B.**

### *Lift Table*

Lexco Engineering & Mfg. Corp. has announced a new hydraulic lift table. It is of steel welded construction and is equipped with floor lock

controlled by foot pedal and toe release to anchor table in position when in use. It is mounted on two 5 in. steel casters and two 5 in. swivel casters.
**For further information circle No. 23 on literature request card, page 48-B.**

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② Longer Tool Life
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- ☐ Bright Heat Treating
- ☐ Stainless Steel Heat Treating
- ☐ Sintering
- ☐ Copper Brazing and Soldering
- ☐ Lead Pot Hardening and Tempering
- ☐ Atmosphere Equipment
- ☐ Other

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# APPLICATION and EQUIPMENT new literature

### 41. Abrasion Tester
Bulletin 5409 on new model standard abrasion testing set describes machine and its operation. *Taber Instrument Corp.*

### 42. Adhesives
New 11-page bulletin on high strength epoxy resin adhesives. Five resins and their uses described. Properties and performance data. *Minnesota Mining and Mfg. Co.*

### 43. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

### 44. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite.*

### 45. Alloys
26-page schedule of nickel alloys and stainless steels. Specification numbers, compositions, properties. *Techalloy Co.*

### 46. Aluminum Alloys
New 61-page book on aluminum casting alloys, their characteristics and behavior. Specifications of government agencies and technical societies. *Alloys & Chemicals Mfg. Co.*

### 47. Aluminum Bronze Alloys
20-page booklet on chemistry, physical properties and uses of aluminum bronze alloys in rolled, extruded and cast forms. *Ampco.*

### 48. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

### 49. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

### 50. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere.*

### 51. Arc Welder
20-page catalog on new submerged arc welders. A.c., d.c., field machines and accessories. *Lincoln Electric Co.*

### 52. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

### 53. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

### 54. Beryllium Copper
New 4-page bulletin 8 on heat treating of beryllium copper. Hardness-response curves. *Penn Precision Products*

### 55. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

### 56. Blackening Copper
Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

### 57. Blast Cleaning
Bulletin 227 on airless blast cleaning machine. Features of construction, sizes, how it operates. *Pangborn*

### 58. Blast Cleaning
New 12-page manual on blast cleaning abrasives. Characteristics of various kinds. SAE shot and grit sizes. *Pangborn Corp.*

### 59. Blast Cleaning
New 56-page catalog on semi-automatic and automatic pressure wet-blast equipment. Applications. *Cro-Plate Co.*

### 60. Brazed Assemblies
New 4-page catalog on facilities for design, development and manufacture of copper and silver brazed assemblies. *Wall Colmonoy*

### 61. Brazing
16-page pocket-sized guide to selective fluxing for low temperature silver brazing. *American Platinum*

### 62. Brazing
16-page reprint on furnace brazing gives advantages of method, design factors and methods of handling assemblies and furnaces for brazing. *Electric Furnace Co.*

### 63. Brazing
Low Temperature Brazing News tells of use of brazing for gas tightness, high strength and good electrical and heat conductivity. *Handy & Harman*

### 64. Burners
New 6-page bulletin 1231-A on fuel burning system. Installations, charts of components. *Orr & Sembower*

### 65. Carbides
4-page bulletin on general-purpose heavy-duty sintered carbide. *Firth Sterling, Inc.*

### 66. Carbon Brick
Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

### 67. Carbon Control
16-page bulletin on equipment for carbon and sulphur determination, including combustion furnaces and other accessories. *Harry W. Dietert*

### 68. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

### 69. Castings
New catalog on forging and casting products contains information on air hardening, oil hardening and other cast-to-shape tool steel specialties. *Allegheny Ludlum*

### 70. Centrifugal Castings
Folder on advantages of centrifugally cast thermalloy. *Electro-Alloys Div.*

### 71. Chemical Processing
Literature on single-package products to produce coatings equal to Dow #17 and Dow #18, and nonelectrolytic process for removing chrome pickle film from magnesium. *Turco Products*

### 72. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

### 40. Barrel Finishing
After a discussion of what barrel finishing is and what parts may be finished by the process, this 76-page book goes into detail on abrasive media, barrel equipment and compounds used. A section on hints to operators takes

up such problems as selection of abrasives, degreasing, loading the barrel, barrel speeds, rinsing and drying of parts, care of barrel and equipment. A glossary of finishing terms concludes the book. *Norton Co.*

### 73. Chromium Stainless
12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

### 74. Chromium Treatment
Reprint describes how chromium impregnating of steel affects properties, how it is done, applications. *Chromalloy*

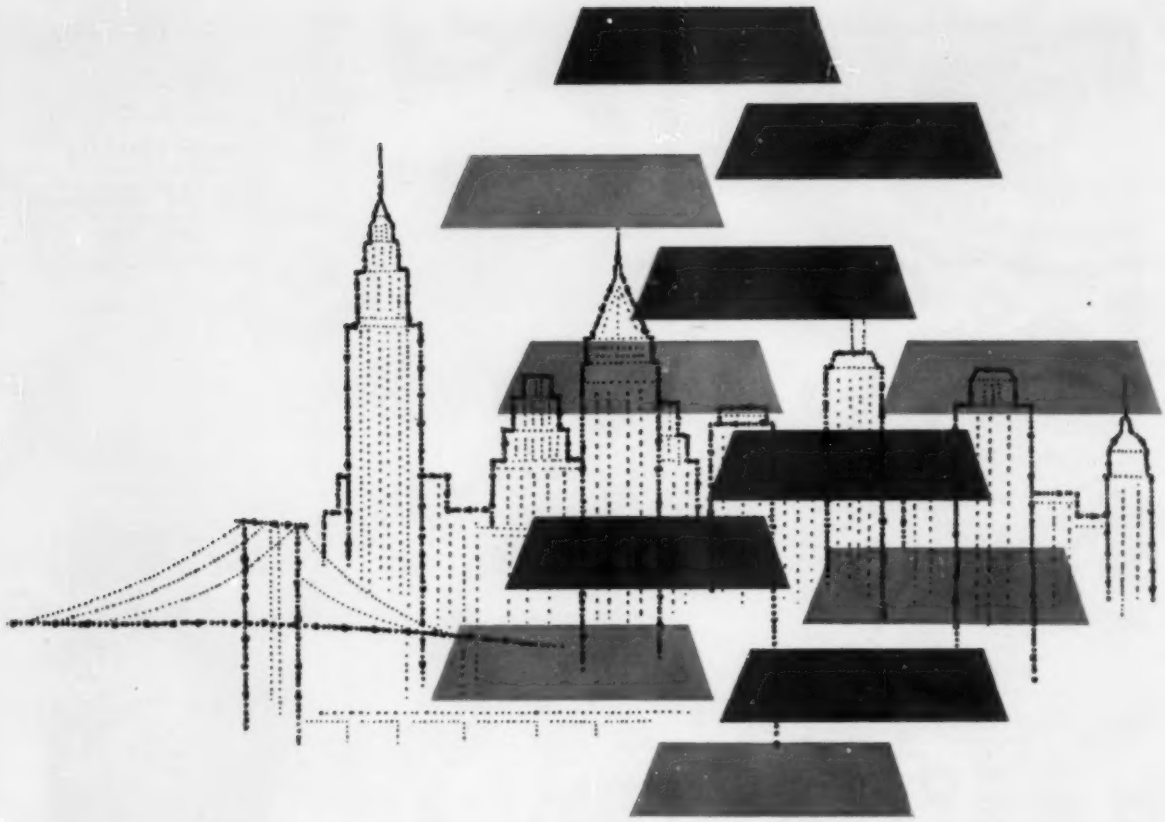
### 75. Cleaner
12-page bulletin on advantages of Immunol, how to use it, applications. *Harry Miller*

### 76. Cleaning
Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

### 77. Cleaning
48-page pocketbook on how to clean aluminum and magnesium. Steps involved, methods, equipment. *Oakite*

### 78. Cleaning
New 8-page booklet on wetting agents, detergents, emulsifiers. *E. F. Houghton*

### 79. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks



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and other fixtures for cleaning and finishing. *Rolock*

**80. Coatings**
New 4-page catalog on heat-proof protective coatings. Basic types, applications, methods of applying and temperature ranges. *Markal Co.*

**81. Combustion Control**
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

**82. Combustion Process**
New 4-page bulletin on combustion process for heat treating and drying ovens, soaking pits. *Steel Processing Co.*

**83. Conductivity Analyzer**
New 12-page catalog on construction, operation and features of thermal conductivity analyzer and electronic recorder. Analyzer determines amount of $CO_2$, $H_2$, He, $CH_4$. *Hays Corp.*

**84. Controlled Atmospheres**
Illustrated literature describes controlled atmosphere installations. *Gas Atmospheres, Inc.*

**85. Controllers**
16-page educational bulletin No. 9 gives data, operation diagrams, schematic drawings of capacitrols. *Wheelco Instruments*

**86. Conveyors**
Bulletin on conveyor standardization describes prefabricated sections for making customized conveyors. *May-Fran Engineering*

**87. Copper Alloys**
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

**88. Copper Alloys**
Wall chart describes 37 brass, bronze and nickel silver casting alloys. Specifications and compositions. *Henning Bros. & Smith*

**89. Copper Alloys**
24-page manual on alloys in rod form. Typical parts. Specifications covering alloys described. *Mueller Brass*

**90. Copper Alloys**
16-page publication E-5 on physical properties and applications of high-strength, corrosion-resistant copper alloys. *American Brass Co.*

**91. Cutting**
Folder gives cutting performance of NewMet on 10 different steels and cast iron. Sizes and prices. *Newcomer Products, Inc.*

**92. Cutting Stainless**
8-page bulletin on shearing, blanking, perforating, friction sawing and flame cutting of stainless. *Crucible Steel*

**93. Cutting Tools**
New 12-page catalog D-56 on aluminum oxide cutting metals, tool tips, throw-away inserts, cylinders and other machine turning and cutting tools. *Metal Carbides*

**94. Descaling**
24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U.S. Ind. Chem.*

**95. Descaling**
Bulletin 1184 on descaling salt for desanding and cleaning castings. *Hooker Electrochemical*

**96. Descaling Stainless Steel**
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

**97. Dew Point Control**
Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

**98. Diamond Polishing**
8-page booklet on metallographic polishing with diamond abrasive and its advantages over silicon carbides. *Elgin National Watch Co.*

**99. Die Casting Machines**
8-page bulletin on model 600 Cleveland die casting machines of cold and hot chamber designs. Special features of machines illustrated. *Cincinnati Automatic Machine Co.*

**100. Die Castings**
31-page booklet on die casting with zinc base alloys. Alloy composition, Metal injection pressure, die temperature, care of dies and like subjects discussed. *Henning Bros. & Smith*

**101. Dies**
48-page manual on power press brake dies describes those in most common use and special purpose dies. Tables of sheet gages and weights. *Cyril Bath Co.*

**102. Ductile Iron**
28-page bulletin gives advantages and applications of ductile iron. Properties. *International Nickel Co.*

**103. Electric Furnaces**
Bulletin HD-153 on furnaces using silicon carbide heating elements for duty to 2600° F. *Hevi Duty Electric Co.*

**104. Electric Furnaces**
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

**105. Electric Furnaces**
Folder on electric furnaces with zone control, temperature indication, automatic control. *L & L Mfg. Co.*

**106. Electric Furnaces**
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

**107. Electron Microscope**
20-page brochure describes ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

**108. Ferro-Alloys**
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

**109. Finishing**
Data sheets on liquid strippers for removing paint and other organic finishes from steel, magnesium and zinc castings. *Northwest Chemical*

**110. Finishing Stainless**
12-page bulletin describes standard mill finishes plus abrasive finishing, electropolishing and special finishes. *Crucible Steel Co.*

**111. Flow Meters**
Bulletin 203 on flow meter for gas used in heat treating. *Waukee Eng'g*

**112. Forging Rolls**
12-page Bulletin 91-B on wide adjustment forging rolls illustrates equipment, lists accessory equipment and gives principal dimensions. *Ajax Mfg.*

**113. Forgings**
Data on forging products and electrically welded composite die sections. *Composite Forgings, Inc.*

**114. Forgings**
Management Guide to the Use of Forgings gives benefits of forgings and the forging process. *Drop Forging Assoc.*

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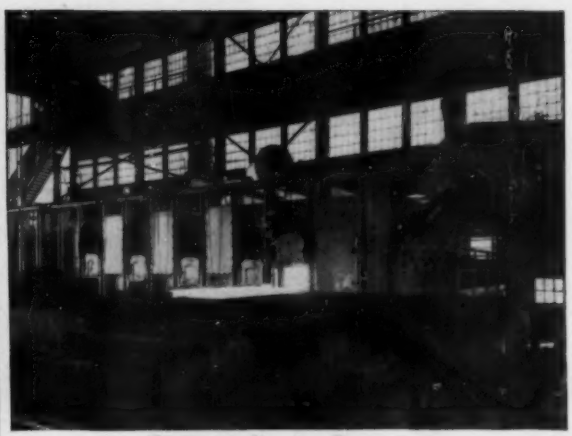

Continuous Heating Furnaces—
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Soaking Pit—Photo Courtesy
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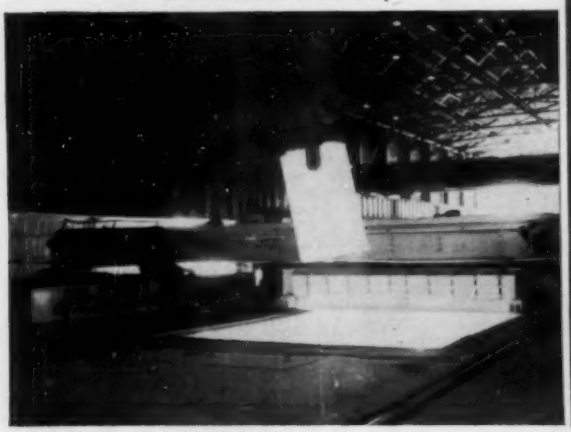

Heat Treating Furnace—
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**116. Forming**
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**117. Furnace Belts**
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**118. Furnaces**
Monthly bulletin on used equipment. *Metal Treating Equipment Exchange*

**119. Furnaces**
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

**120. Furnaces**
4-page bulletin on field-erected production furnaces. Heating elements and radiant gas-fired tubes described. *Lindberg Industrial Corp.*

**121. Furnaces**
Bulletin 1250-T on bell retort furnaces describes atmosphere system, construction and dimensions. *American Gas Furnace*

**122. Furnaces**
High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

**123. Furnaces**
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

**124. Furnaces**
Folder on new sizes, specifications for soft metal reverberatory furnaces. *Eclipse Fuel Engineering*

**125. Furnaces**
44-page Catalog 112, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

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Bulletin 424R on gas, oil, and electric revolving retort furnaces for annealing, hardening, drawing. *W. S. Rockwell Co.*

**127. Furnaces**
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**128. Gas Analysis**
New 16-page booklet TD-507 on instruments for continuous analysis. *Arnold O. Beckman, Inc.*

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Bulletins on furnaces for all types of heat treating and hardening, both standard and custom designed. *Pacific Scientific Co.*

**130. Gold Plating**
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**131. Graphite**
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8-page booklet on engineering and purchasing requirements for gray iron castings. Specific data which should be given in placing an order or asking for a quotation. *Gray Iron Founders' Society*

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**134. Hardness Tester**
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**135. Hardness Tester**
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

**136. Hardness Testers**
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage International*

**137. Hardness Testers**
20-page book on hardness testing by Rockwell method. *Clark Instrument*

**138. Hardness Testers**
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

**139. Hardness Testing**
8-page catalog B-953 on principles and standards of Brinell hardness testing, and types of machines. *Steel City Testing Machines*

**140. Hardness Testing**
Bulletins on Wolpert-Gries machines for standard Rockwell tests. Motorized reflex type for Brinell tests. *Gries Industries*

**141. Heat Treating**
Bulletin on completely mechanized heat treat lines. 24 basic mechanisms. Steps in building automated lines. *Surface Combustion Corp.*

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New edition of 73-page vest pocket data book on heat treating. Charts, tables, diagrams and factual data. *Sunbeam Corp.*

**143. Heat Treating**
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

**144. Heat Treating**
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

**145. Heat Treating**
Reference sheet gives procedures for preparing parts for heat treating. *Metal Treating Institute*

**146. Heat Treating Ammonia**
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

**147. Heat Treating Belts**
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

**148. Heat Treating Fixtures**
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

**149. Heat Treating Fixtures**
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

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12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

**151. Heat Treating Furnaces**
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

**152. Heat Treatment**
Precision heat treatment of jet aircraft parts in Metal Minutes No. 5, Vol. 15. *Sunbeam Corp.*


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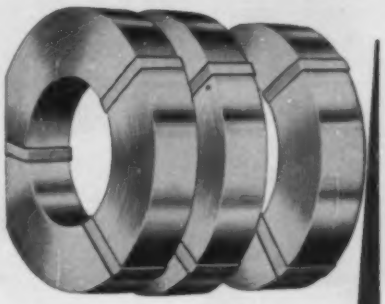

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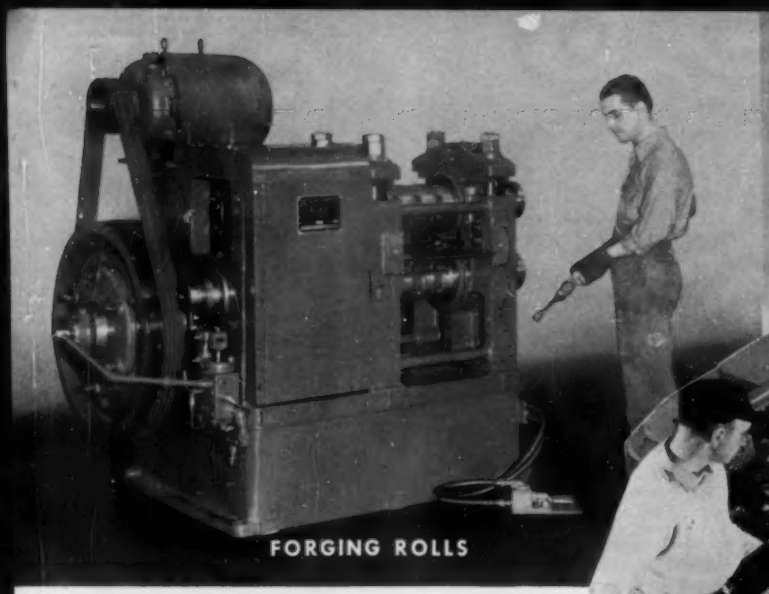

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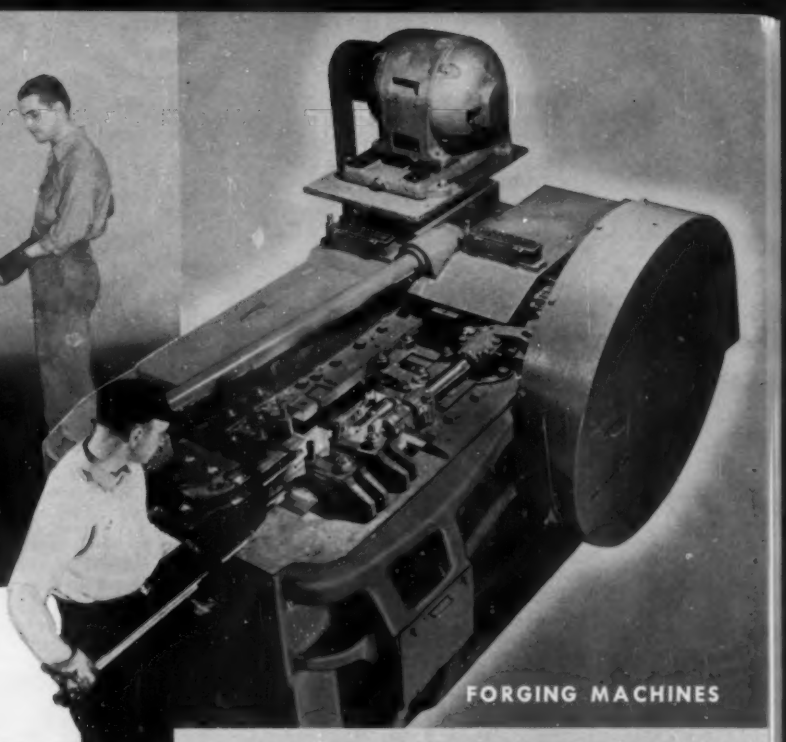

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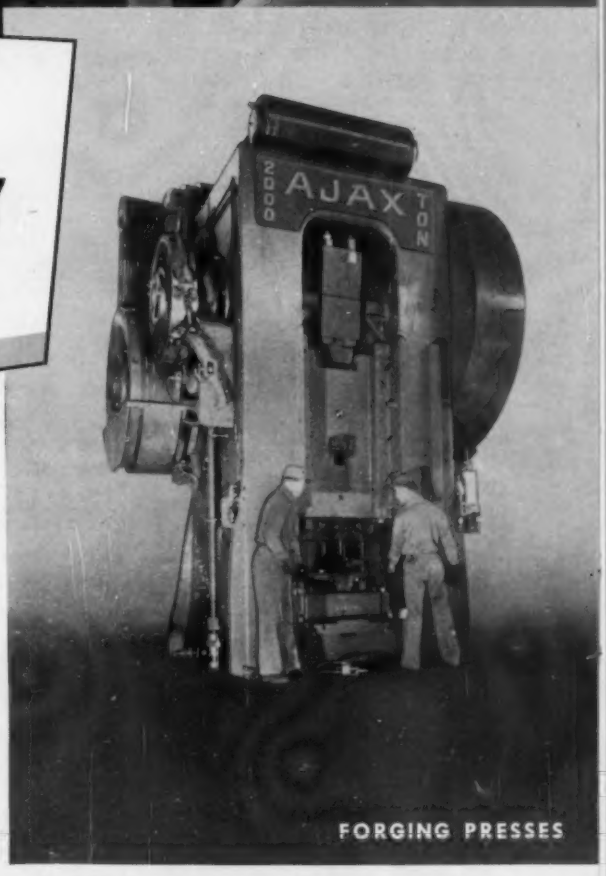


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**153. Heating Elements**
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

**154. Heating Time Calculator**
Slide chart gives heating time in salt baths for steel sections of different diameters. *Ajax Electric*

**155. High-Alloy Castings**
16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

**156. High-Strength Steel**
Folder on medium manganese copper-bearing high strength steel. Properties. Corrosion resistance. *Youngstown Sheet and Tube*

**157. High-Temperature Materials**
Folders on ThermoSpray gun for spraying powdered ceramics and metals without compressed air. *Metallizing Engineering Co.*

**158. High-Temperature Steels**
32-pages of data sheets on medium carbon pearlitic alloy steels for high temperature applications. Room and high temperature properties. Hot working characteristics. *Timken*

**159. Identifying Stainless**
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

**160. Induction Heating**
8-page bulletin on low and high frequency equipment. Charts on depth of hardness, frequency selection chart. *Magnethermic Corp.*

**161. Induction Heating**
Folder 15C8053A gives advantages of induction heating and specifications and dimensions of induction heater. *Allis-Chalmers.*

**162. Induction Heating**
12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

**163. Induction Heating**
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

**164. Induction Melting**
4-page folder (R-42) on line frequency induction melting furnaces in modern zinc and aluminum die casting plant. *Ajax Engineering*

**165. Induction Melting**
16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and nonferrous metals. *Ajax Electrothermic*

**166. Induction Melting**
Bulletin 70 on furnace. Controls, designs. *Inductotherm Corp.*

**167. Industrial Heating**
Booklet on process heating operations for light metals. *Michigan Oven Co.*

**168. Inspection**
Descriptive information and instructions for new inspection process to detect surface flaws on all ferrous and nonferrous metals. *Zaco Laboratories*

**169. Inspection**
16-page bulletin on how, why and where to use magnetic particle inspection. *Magnaflux Corp.*

**170. Inspection**
New 16-page catalog on illuminated Borescopes for industrial inspection of deep recessed areas. *National Electric Instrument Co.*

**171. Instruments**
12-page brochure on instruments for chemical process applications. *Leeds & Northrup*

**172. Insulating Firebrick**
8-page bulletin R-43 gives description of relationship between heat losses and weight of refractory linings. *Refractories Div., Babcock & Wilcox*

**173. Insulators**
Bulletin P1-55 on insulators and insulating tubing. *McDanel Refractory*

**174. Investment Casting**
8-page bulletin on wax injection presses for investment casting. *Alexander Saunders*

**175. Laboratory Equipment**
16-page Laboratory Spotlight lists optical equipment and instruments for metallurgical laboratory. Cut-off machines, polishing tables, etc. *Harshaw Chemical*

**176. Laboratory Furnace**
Box furnace with cooling chamber for use to 3100° F. described in bulletin GEA-4713. *General Electric*

**177. Laboratory Furnaces**
Bulletin No. 310 on high temperature electric tube furnaces for laboratories. *Burrell*

**178. Laboratory Furnaces**
Data on nonmetallic resistor furnaces for research, testing or small-scale production. *Harrop Electric Furnace*

**179. Leaded Alloy Steel**
8-page bulletin gives mechanical properties of Rycut 40, medium carbon fast machining leaded alloy steel. Case studies. *Ryerson*

**180. Leaded Steel**
8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

**181. Low-Alloy Steel**
16-page bulletin A-61 gives corrosion resistance, forming and working qualities, design factors. *International Nickel*

**182. Low-Temperature Alloys**
New bulletin on some properties of nickel alloys at low temperatures. Wrought and cast alloys. *International Nickel Co.*

**183. Lubricant**
New 12-page bulletin on moly-sulfide as a lubricant additive. Lubricating characteristics as demonstrated by standard tests. *Climax Molybdenum*

**184. Lubricant**
Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Molykote*

**185. Lubricant**
Literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

**186. Lubricants**
8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. *Grafo Colloids*

**187. Lubricants**
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**188. Machining Alloy Steels**
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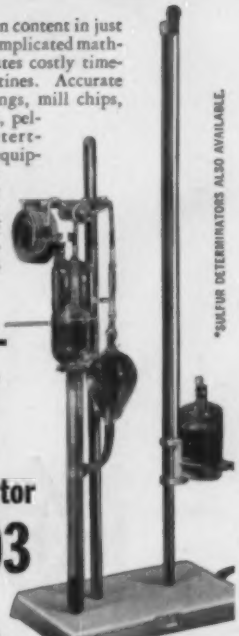

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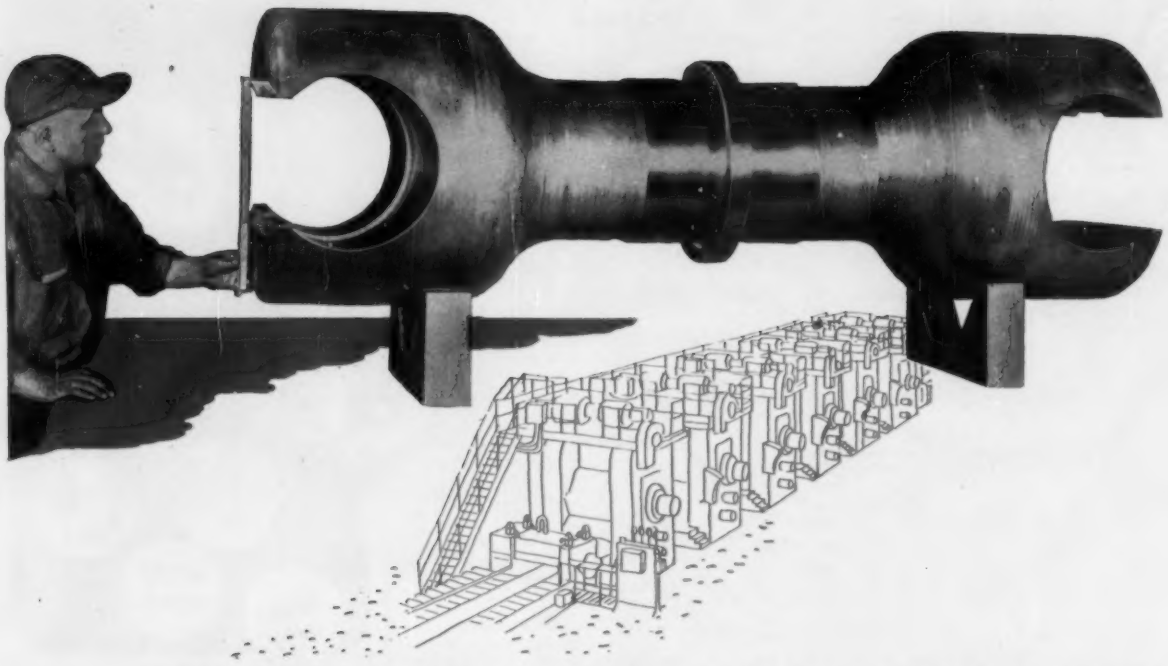

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**196. Metal Powders**
8-page bulletin 561 gives specifications, properties and uses of metal powders. *Metals Disintegrating Co.*

**197. Metallograph**
12-page book on desk-type metallograph. *American Optical*

**198. Metallographic Equipment**
12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

**199. Metallographic Polishing**
AB Metal Digest discusses features of various models of metallographic polishing equipment. *Buehler, Ltd.*

**200. Microhardness Tester**
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

**201. Microscopes**
Catalog on metallograph and several models of microscopes. *United Scientific*

**202. Molybdenum Carbides**
New 6-page bulletin on applications, physical, chemical and mechanical properties, preparation of molybdenum carbides and nitrides. *Climax Molybdenum*

**203. Nickel Alloys**
38-page handbook on wire, rod, strip of Monel, Inconel, nickel and nickel clad copper. *Alloy Metal Wire Co.*

**204. Nickel Plating**
16-page bulletin gives instructions for plating by the sulfamate nickel process. *Hanson-Van Winkle-Munning*

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Data on process for nitriding stainless steel. *Standard Steel Treating*

**206. Nondestructive Testing**
Data on new nondestructive thickness tester. *Unit Process Assemblies*

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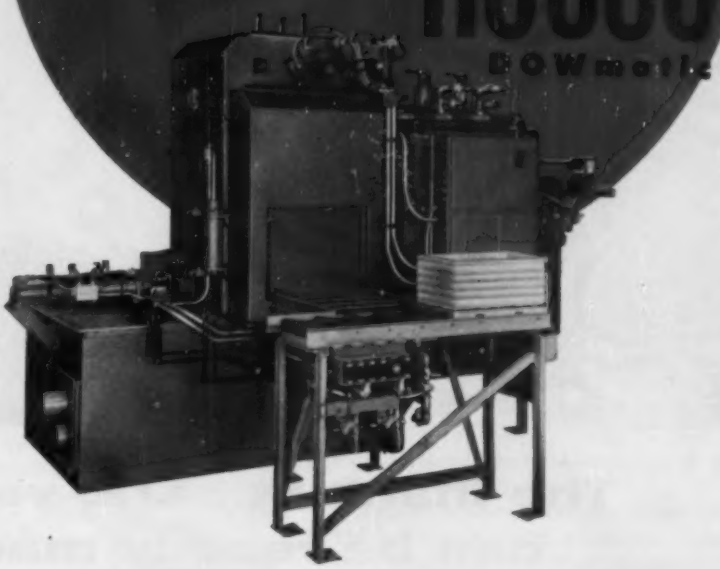

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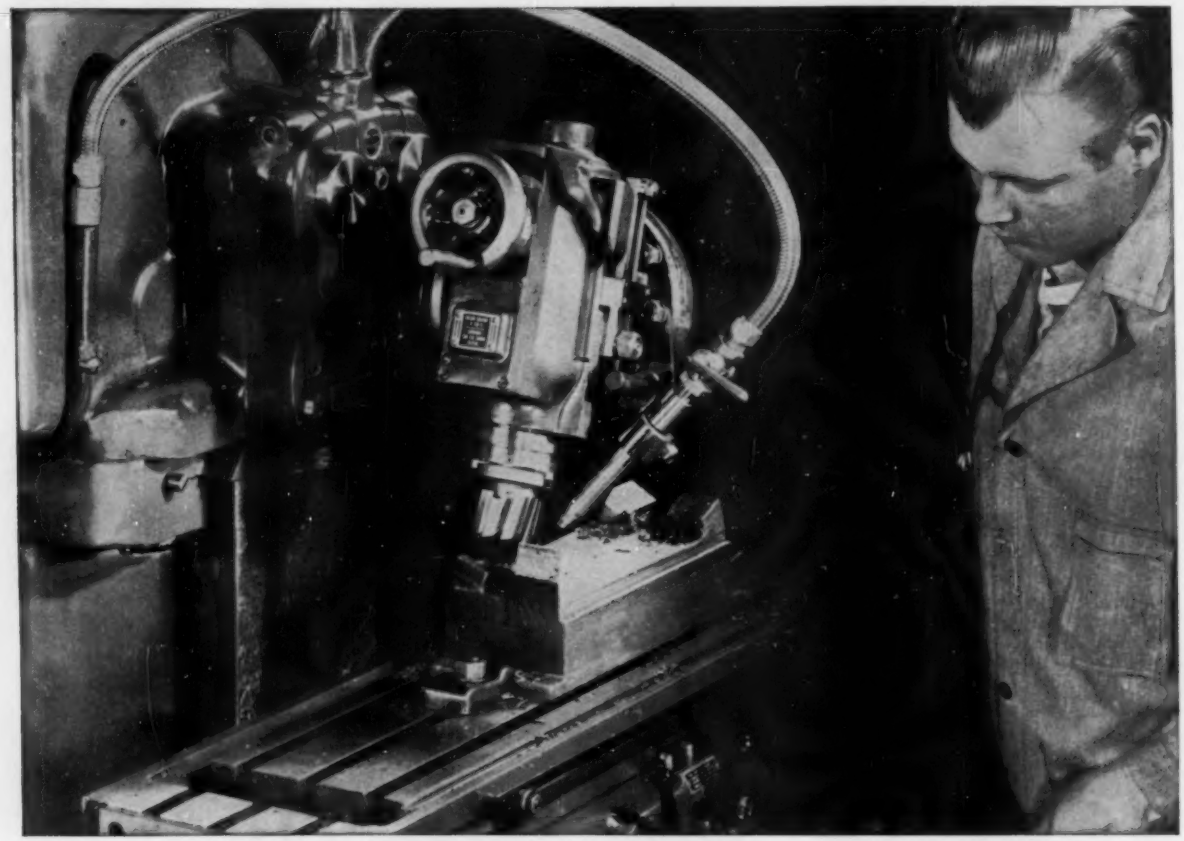

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Mallory-Sharon guarantees that MST titanium and titanium alloy mill products contain no more than 1/10 of 1% carbon. This avoids the formation of hard carbides which greatly reduce machineability.

For bulletin on titanium machining recommendations, please write Dept. F-1.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti SHARON

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LOW TEMPERATURE SILVER BRAZING ALLOY

The Marshall Brass Company of Marshall, Michigan are outstanding manufacturers of brass fittings for gas, water and heating systems.

Here are typical examples of well-conceived engineering that improved product and product production while cost of manufacture was drastically reduced.

These Marshall Valve Bodies were formerly cast in one piece. They were then machined, ground and buffed at considerable cost. In the present procedure, the valve bodies and parts are produced on screw machine equipment, assembled and Silvaloy brazed. Grinding, and buffing are virtually eliminated. The joints are strong and leakproof . . . plating is easier . . . plating results are much improved.

The new method of manufacture is certainly highly successful. Rejects are kept below 1%—a far more favorable percentage than was possible when cast bodies were used. Savings in cost of manufacture have been estimated at approximately 35%.

Silvaloy Brazing Alloys arc APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy Distributor for information or technical assistance. ★ ★ ★ ★ ★ ★

**FREE:** These two complete reference manuals for low temperature silver brazing and fluxing are available upon request. Send for either one or both.

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ENGELHARD INDUSTRIES

(Continued from page 45)

**208. Nonflammable Rust Preventive**
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

**209. Oil Quenching**
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

**210. Oil Quenching**
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

**211. Phosphating**
Folder includes general discussion of phosphating, how it works and use of coatings as bonds for paint or other organic finishes. *Turco Products*

**212. Photomicrography**
Catalog E-210 on sliding base, high or low power photomicrographic equipment. *Bausch & Lomb*

**213. Pickling Baskets**
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

**214. Pickling Baskets**
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

**215. Plastic Materials**
12-page condensed file of leading plastics and the properties and uses. Fabricating techniques. *Bakelite Co.*

**216. Plating**
New 8-page brochure on test equipment for plating baths. Controls, anodes, cathodes, agitators, rectifiers. *R. O. Hull*

**217. Potentiometer**
New 64-page bulletin P1245A on electronic potentiometer and bridge instruments for recording, controlling. *Bristol*

**218. Powdered Iron**
Properties of Plast/Iron with and without copper. *Plastic Metals Div.*

**219. Powdered Metals**
Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc*

**220. Powdered Metals**
Data sheets on sintered iron, steel, brass alloys, bronze alloys and bronze filters. *Dixon Sintaloy, Inc.*

**221. Precision Casting**
12-page book on alloy selection and design for investment casting. *Arwood Precision Casting*

**222. Precision Casting**
16-page booklet on methods used to produce castings by the "lost wax" method. Compositions of alloys used. *Crucible Steel*

**223. Precision Casting**
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

**224. Protecting Tubes**
New bulletin 1000-56 on ceramic protecting tubes lists sizes and materials. *Claud S. Gordon*

**225. Pyrometer**
12-page bulletin on contact pyrometer for surface temperatures describes and illustrates instrument and its uses. *Illinois Testing Laboratories*

**226. Quenching Oil**
New Bulletin 45 on quenching oil treats mechanism of quenching and explains how Sunquench 78 aids. *Sun Oil*

**227. Radiation Products**
8-page catalog on equipment for nuclear research. Radioactive sources, shielding and exposure equipment, instruments, services. *Budd Co.*

**228. Recirculating Furnace**
Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment*

**229. Recorders**
New 4-page data sheet E-ND46(6) on millivolt recorders. Specifications. *Leeds & Northrup*

**230. Refractories**
New bulletin, 1992, on two high temperature Alundum castable refractories. Properties and how to use them. *Norton*

**231. Refractories**
24-page bulletin R-35 on castables, insulating concrete mixes, plastics, ramming mixes, and mortars. *Babcock & Wilcox*

**232. Refractories**
24-page bulletin on physical and chemical properties of super refractories. *Refractories Div., Carborundum*

**233. Refractories**
8-page bulletin on castable refractories tells how to apply, properties, how much to use and where to use them. *Refractory & Insulation Corp.*

**234. Residual Stresses**
32-page, pocket-size booklet on residual stresses in cold-finished steel bars and their effect on manufactured parts. *La Salle Steel*

**235. Rhodium Plating**
Data on properties, thicknesses required, costs, operation, applications. *Technic*

**236. Roll Formed Shapes**
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

**237. Rolling Mills**
New 36-page book catalogs rolling mills and rolling mill auxiliary equipment for ferrous and nonferrous metal. *Waterbury Farrel*

**238. Rotary Knives**
New bulletin on various types of slitting knives and other tools designed for unusual requirements. *Cowles Tool Co.*

**239. Salt Bath Carburizing**
5-page booklet on liquid carburizing with advantages and disadvantages of the salt bath process. *American Cyanamid*

**240. Salt Bath Furnace**
4-page reprint No. 156 on salt bath furnace for brazing and carburizing, brazing, and hardening. *Ajax Electric Co.*

**241. Salt Bath Furnaces**
Data on salt bath furnaces for batch and conveyorized work. *Upton*

**242. Salt Baths**
32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. *E. F. Houghton*

**243. Salt Baths**
Bulletin 200 tells about different types of baths and operating characteristics of each. Table of bath recommendations for various steels. *A. F. Holden*

**244. Sand Systems**
Bulletin No. SL-3 shows layout of system and controls. *Harry W. Dietert Co.*

**245. Saws**
Catalog C-55 describes 35 models of metal-cutting saws. *Armstrong-Blum*

**246. Seamless Tubing**
New 4-page catalog on small seamless tubing. Metal shielded wire. *Uniform Tubes, Inc.*

**247. Shear**
Bulletin on bar and billet shear for rounds, squares, flats, billets and structurals, either hot or cold. *Hill Acme Co.*

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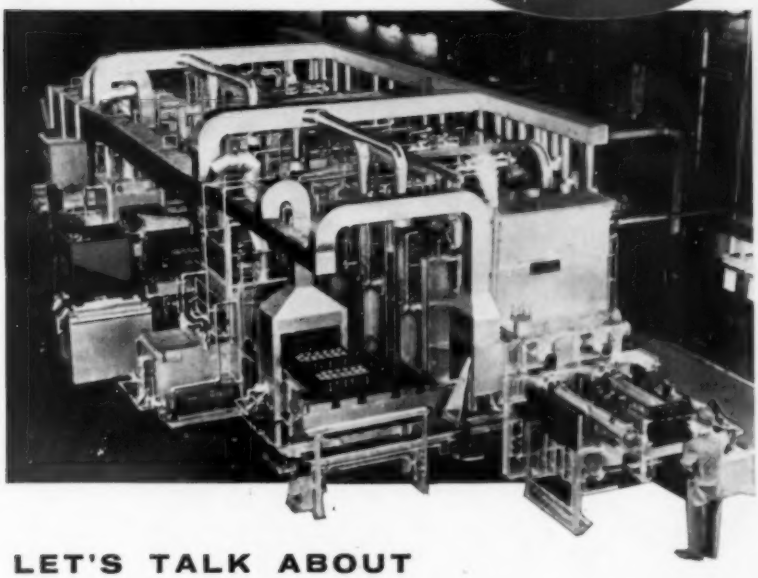

## LET'S TALK ABOUT

# HEAT TREAT STANDARDS

When you take a long look at today's heat treat standards, you'll find that many of them were originated or perfected by Holcroft and Company.

For example, back in 1922 the removable electric heating element was developed. As far back as 1934, Holcroft recognized the significance and importance of equilibrium constants and their value to controlled atmosphere heat treating. And in 1945, was initiated the use of refractories and ceramics in place of scarce and expensive nickel-chrome alloys in vital parts of the furnace. These are only three of many, many innovations which have become heat treat standards in the industry.

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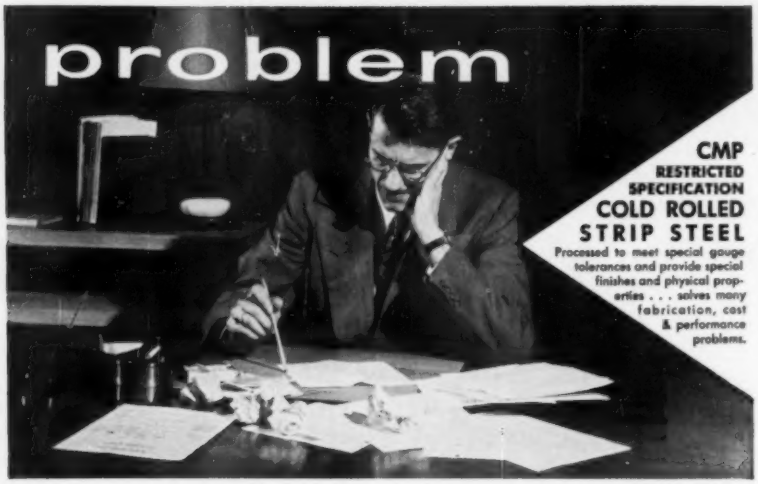
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Processed to meet special gauge tolerances and provide special finishes and physical properties . . . solves many fabrication, cost & performance problems.

Helping to overcome metal fabricating difficulties, improving products without skyrocketing costs or just getting costs down are usual events with **CMP.**

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### 248. Shell Molding
New 32-page booklet on shell molding process, resins, machinery, design considerations, blowing of shell cores and shell molds. *Barrett Div., Allied Chemical & Dye Corp.*

### 249. Silver Brazing
8-page Bulletin B-80 on low temperature silver brazing alloy. Joint preparation, strength of brazed joint, ductility and corrosion resistance. *United Wire and Supply Corp.*

### 250. Slitter
New 16-page booklet on rotary gang slitters. Sheet and coil slitting methods summarized. *Stanat Mfg.*

### 251. Soldering Fluxes
Discussion in "Federated Metals Digest", Vol. 3, No. 1, of various types and their advantages. *Federated Metals*

### 252. Sonic Thickness Tester
Measurement of wall thickness from one side by sonic method. *Branson*

### 253. Spark Testing
20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

### 254. Springs
8-page bulletin on spring design. Stress and deflection formulas for various types of springs. Physical properties of commonly used spring materials. *Associated Spring*

### 255. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

### 256. Stainless Steel
40-page Design Handbook gives properties, specifications, applications, design data on springs. *Alloy Metal Wire*

### 257. Stainless Steel
Two booklets on 200 series of low nickel, austenitic stainless steels, give applications and properties compared with 300 series. *Republic Steel*

### 258. Steel 52100
New stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

### 259. Temperature Measuring
New 24-page catalog of heat radiation detectors for continuous temperature measurement to 5000° F. *Leeds & Northrup*

### 260. Temperature Measuring
Bulletins on Tempilstiks and Tempilaq describe products and tell how to use them. *Tempil® Corp.*

### 261. Temperature Measuring
8-page catalog 175 on optical, micro-optical, radiation, immersion and surface pyrometers. *Pyrometer Instrument Co.*

### 262. Test Bars
Specifications of new cast-to-size tensile test bar for investment cast materials. *Investment Casting Institute*

### 263. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

### 264. Testing Equipment
80-page illustrated catalog lists over 130 testing and measuring tools for laboratory and production-line use. *General Electric*

### 265. Testing Machines
12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

### 266. Testing Machines
New 40-page bulletin on electromatic universal testing machines. Specifications for standard machines and descriptions of loading, weighing and indicating systems. *Tinius Olsen*

### 267. Testing Machines
28-page catalog on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

### 268. Thermocouple Alloys
20-page booklet on chromel-alumel alloys gives sizes, temperature-millivolt equivalents, standards, applications. *Hoskins Mfg.*

### 269. Thermocouples
20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. *Gen. Electric*

### 270. Thermocouples
Bulletin on miniature shielded thermocouples. Uses, calibrations, temperature ranges, materials of construction. *Thermo Electric*

### 271. Thickness Gage
Folder on pocket-size gage. How to use it. *Ferro Corp.*

### 272. Titanium
Folder on commercially pure, unalloyed titanium gives properties, types supplied, forming methods, cleaning. *Mallory Sharon Titanium*

### 273. Titanium Alloy
12-page booklet on C-120AV titanium alloy. Physical properties, elevated-temperature properties, creep, fatigue, welding, machining, heat treatment. *Rem-Cru*

### 274. Tool Steel
Wall chart showing more than 300 varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

### 275. Tool Steel Color Guide
Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

### 276. Tool Steels
Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

### 277. Tungsten
20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric*

### 278. Vacuum Calculator
Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

### 279. Vacuum Furnaces
8-page bulletin 552 on high vacuum furnaces. Equipment and methods for vacuum melting. Vacuum treating—annealing, heat treating, degassing, brazing, sintering. *High Vacuum Equipment Corp.*

### 280. Vacuum Metallurgy
Information memo tells of materials handling in vacuum metallurgy. *Consolidated Electrodynamics*

### 281. Vacuum Metals
File of data on vacuum-melted metals and their applications for bearings and the chemical industry. Development of the vacuum metals. *Vacuum Metals Corp.*

### 282. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

### 283. Welding Assemblies
8-page folder shows new wire feed units, control units and accessories. Suggestions for combinations to produce various kinds of welding installations. *Linde*

### 284. Welding Electrodes
Report No. W5410 on low hydrogen electrodes for high alloy steels. *Harnischfeger*

### 285. Wire Cloth
No. 3 of The Cambridge Wire gives applications of wire cloth in ceramics, metalworking, food, chemical and other industries. *Cambridge Wire Cloth*

JANUARY, 1957

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| 24 | 49 | 74 | 99 | 124 | 149 | 174 | 199 | 224 | 249 | 274 | |
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# Save by using specialized refractories

Many refractories problems in metal-working furnaces have been solved *economically* by the use of B&W specialized refractory castables. Each ferrous or non-ferrous furnace application requires a specific combination of properties to meet the service conditions. Whether your problem is high temperatures, abrasion and erosion, slag attack or the need for insulation, to name a few, you will find the refractory castable best suited to your requirements in B&W's line. Shown here in digest form are data on the widely used B&W refractory castables for metal-working furnaces:

## B&W Refractory Castables for Metal Working Furnaces

| | Temp. F | PROPERTIES | TYPICAL APPLICATIONS |
|---|---|---|---|
| B&W Kaocast | 3000 | High resistance to spalling and slag attack. Low volume change and negligible reheat shrinkage. | Soaking pit covers, linings of high temperature heating and forging furnaces, burner blocks, electrode linings of electric furnace roofs, linings of non-ferrous metal furnaces. |
| B&W Kaocrete 32 | 3200 | High strength, exceptional refractoriness, unusual volume stability, excellent resistance to spalling. | Can be used in applications similar to those of B&W Kaocast and where higher refractoriness is required. |
| B&W Kaocrete D | 2500 | Sufficient strength and hardness to withstand abrasion, considerable physical abuse and erosion. | Aluminum melting furnaces, linings and car tops in heat treating furnaces, as well as in sections of a wide variety of furnaces that are subject to scraping by hand tools or other mechanical abuse. |
| B&W Kaocrete A | 2600 | Resists reducing atmospheres. Has good resistance to erosion, abrasion and thermal shock. | Annealing furnace bases and other applications where resistance to reducing atmospheres is essential. Also as a general purpose castable for linings in medium temperature service. |
| B&W Kaocrete B | 2300 | Has an adhesive plastic texture particularly suited for vertical or overhanging constructions. Excellent for plastering. | Patching linings and baffles and for any application where plastering rather than gunning or casting is required. |
| B&W Kaocrete LI | 2700 | High alumina content, exceptionally high strength for resistance to abrasion and erosion. | Aluminum furnace linings where high alumina content is important. |
| B&W Kaolite 20 | 2000 | Offers castable's fast, low cost installation plus insulation. Has refractoriness, light weight and low heat conductivity and, in addition, will resist reducing atmospheres. Can be poured or gunned. | Aluminum melting, heating and heat-treating, annealing and forge furnaces. Also for general maintenance and patching. |
| B&W Kaolite 22 | 2200 | Has the same properties as B&W Kaolite 20. Can be used for higher temperatures but not in reducing atmospheres. | |

Send for your copy of B&W Bulletin R-35. It gives additional information on B&W's versatile refractory castables.

**B&W REFRACTORIES PRODUCTS:** B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

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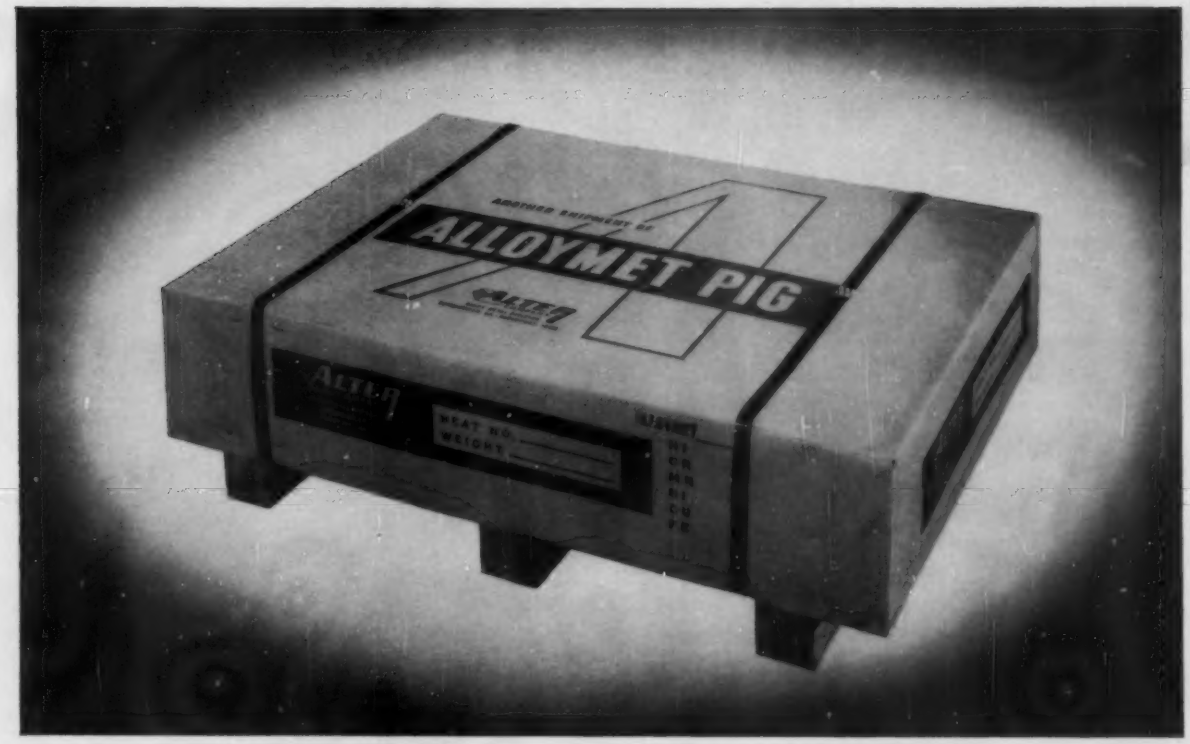


# NEW "BOX LUNCH" of NICKEL ALLOY

## speeds feeding of electric furnaces

26 nickel alloy pigs, each weighing about 50 pounds, travel inside this new palletized package. Weight and certified analysis are in plain view at all times. All fiberboard, it can go into the electric furnace "as is." It weighs only ¼ as much as a wooden pallet. Saves on transportation costs. Discourages pilferage. Speeds handling.

Users are already enthusiastic about this new nickel alloy package. Like the quality product it contains, it serves as a further example of the exacting care Alter Company exercises in every phase of the production of alloy metals.

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# ELECTROMET SERVICE MAKES

ELECTROMET makes available many technical services to help metal producers make the most effective use of alloys.

Experienced ELECTROMET engineers work hand-in-hand with steel melters, iron foundrymen, and nonferrous producers in the selection and use of alloys and alloying materials. Their consultation service includes furnace techniques and melting operations as well as casting, rolling, and other forming practices. ELECTROMET's engineers always have recourse to the vast technical experience of:

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In this way, ELECTROMET translates technical improvements and discoveries into an invaluable service available to all customers—a bonus when you buy ELECTROMET's quality products.

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***...THANKS TO ALLOYS***

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Trade-mark

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# THE DIFFERENCE!

Experienced ELECTROMET engineers are always ready to assist customers in the selection and use of alloys and metals for the production of steel, iron, and non-ferrous metals.

Electrolytic Chromium Metal, Chromium Briquets.

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**MANGANESE**—13 Ferromanganese Grades, MANSILOY Alloy, 3 Silicomanganese Grades, Electrolytic Manganese Metal, Silicomanganese and Ferromanganese Briquets, MANTEMP Ferromanganese.

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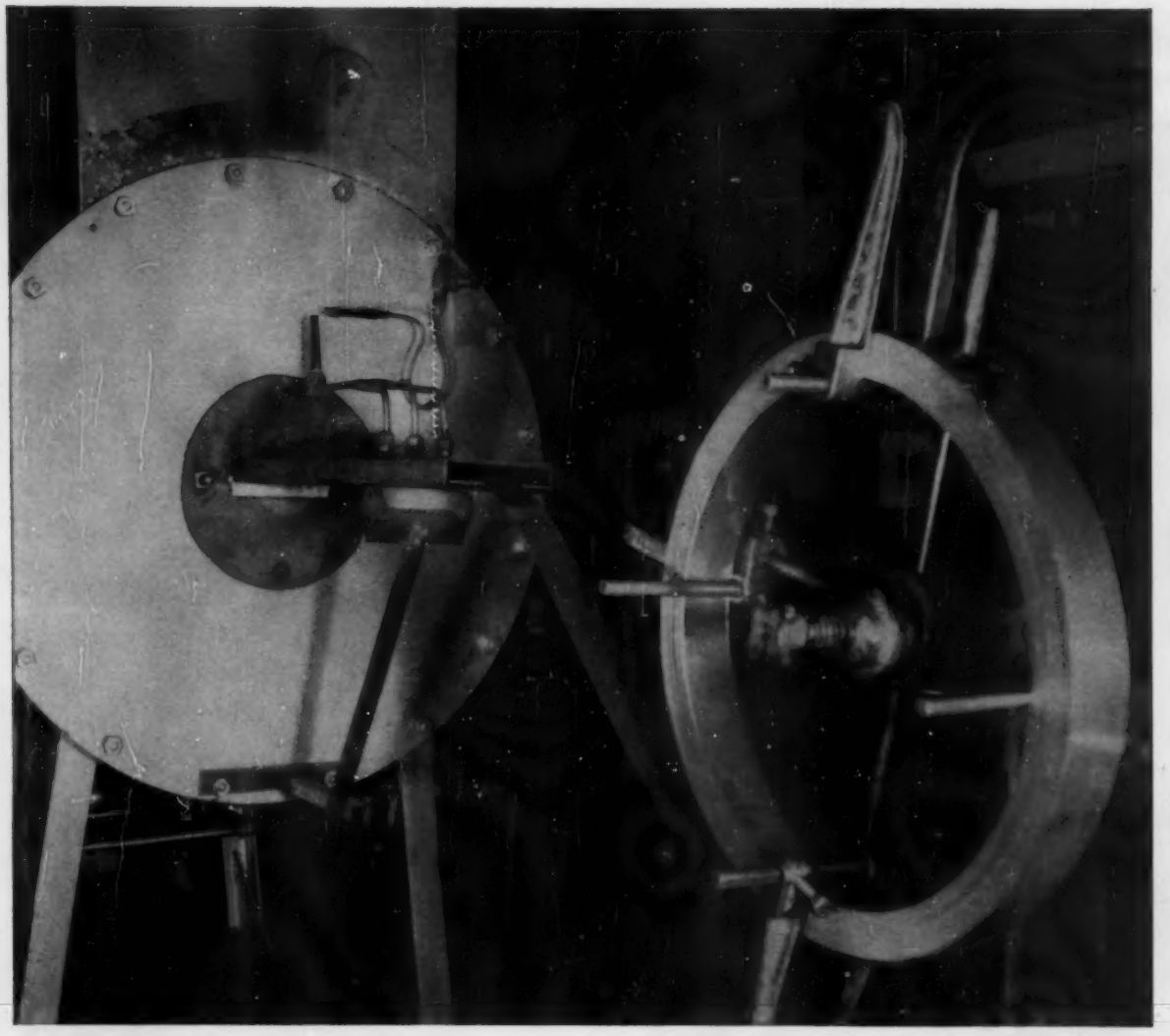
**TITANIUM**—Titanium Metal Sponge, Ferrotitanium, Silicon-Titanium, Manganese-Nickel-Titanium, Aluminum-Titanium, 70% Ferrotitanium (Boron-Bearing).

**TUNGSTEN**—Ferrotungsten, Tungsten Powder, Calcium Tungstate, Ammonium Paratungstate, Self-Reducing Tungsten.

**VANADIUM**—Ferrovanadium, Vanadium-Aluminum, Vanadium Oxide (Fused), Sodium Polyvanadate, Ammonium Metavanadate.

**ZIRCONIUM**—2 Zirconium-Silicon Alloys, Nickel-Zirconium.



# *GAS* heat-treats metal parts in your precision *Hamilton* watch

Gas is used by the Hamilton Watch Company to heat-treat metal parts of its watches—down to the tiniest balance staffs. Gas-fired strip furnaces maintain a temperature of 2,000 degrees to temper the strip used in processing hairsprings and mainsprings of all Hamiltons. The hairspring of a watch is finer than a human hair—yet, due to modern metallurgy and heat-treating methods, this delicate piece of steel may last a lifetime.

Gas is used in heat-treating processes at Hamilton because it is clean, economical, and permits exact temperature control. Throughout industry Gas and modern Gas equipment provide the most satisfactory method of heat processing. For information on how Gas can help you in your production operations, call your Gas Company's industrial specialist. He'll be glad to discuss with you the economies and outstanding results you always get with Gas and modern Gas industrial equipment. *American Gas Association.*

# now, Crucible low nickel stainless steels that meet many of your needs . . .

Here are two *new* Crucible grades, Rezistal type 201 and 202 that are similar in quality and properties to types 301 and 302 . . . but with desirable features all their own.

In the annealed condition, for example, Rezistal 201 and 202 have about 10% higher strength than 301 and 302, yet maintain almost identical ductility. This means that these grades can be fabricated with ease equal to their counterparts. In addition, their mill finishes and corrosion resistance to a wide variation of media compare most favorably with 301 and 302.

To sum up: Rezistal 201 and 202 have practically all the desirable properties of 301 and 302, *plus* some of their own. And they're available *promptly* in all forms. Write now for data sheets fully covering the properties of these new stainless grades. *Crucible Steel Company of America, Dept. AMP, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

**CRUCIBLE** first name in special purpose steels

**Crucible Steel Company of America**

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

# SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

## NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

ZINC and CADMIUM: Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

COPPER, BRASS, BRONZE: Metallic bright, yellow.

ALUMINUM ALLOYS: Clear, iridescent yellow, brown.

MAGNESIUM ALLOYS: Metallic bright, iridescent yellow-red, brown.

SILVER: Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases, sizeable savings in the cost of buffing and electroplating are realized.

### WHAT IS IRIDITE®?

**Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.**

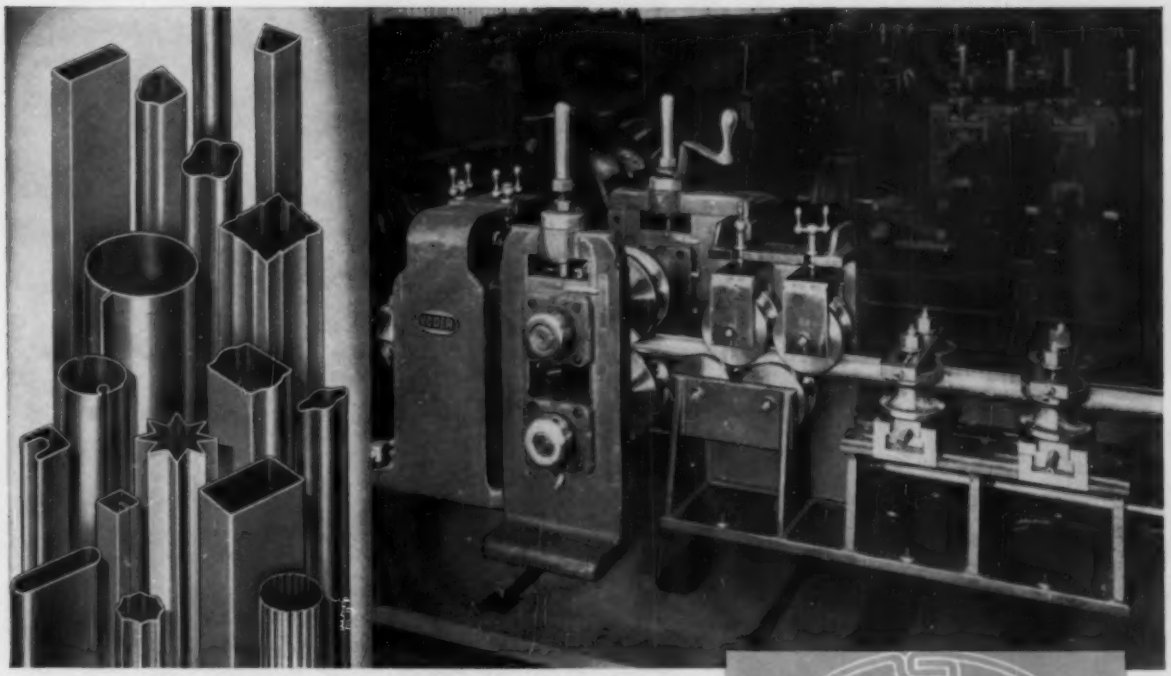
On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least $15,000 a year on maintenance of racks alone and another $40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.



*Lock-Seaming attachment at exit end of forming machine.*

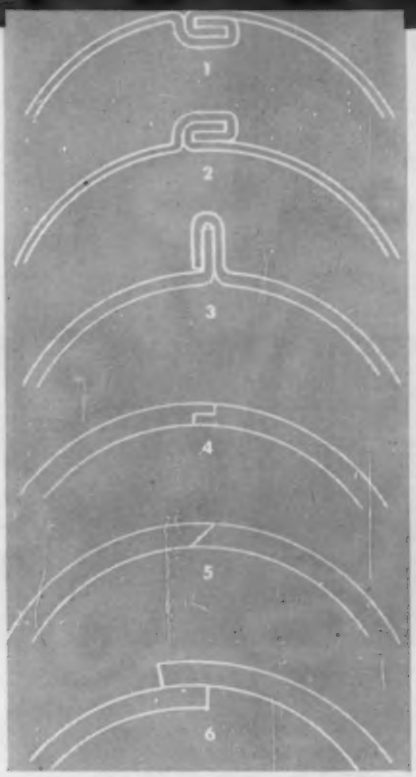
# COLD ROLL FORMING TUBULAR SHAPES

Among the wide variety of things you can make on a Yoder Cold Roll Forming machine are round, square, oval, rectangular and other tubular shapes, such as illustrated at left above. The seams may be open, lapped, butted, dovetailed, interlocking, etc.—as indicated in Figures 1 to 6 at the right.

Millions of feet of such unwelded tubular shapes are made from coiled strip for conductor pipe, bedsteads, lamp stands, window channel, wiring raceways, carrying rods, etc. Production ranges from 20,000 to 50,000 feet per day, with only one operator and a helper.

Yoder offers you the cooperation of their engineering staff for designing and adapting their cold roll forming machines, auxiliaries, and tooling, for the low cost production of structurals, mouldings and trim, panels, tubular and other shapes, to meet individual needs.

The Yoder book on Cold Roll Forming is a complete, illustrated text on the art and the equipment needed for performing a variety of operations which can be combined with cold roll forming, at little or no extra labor cost. A copy is yours for the asking.




**THE YODER COMPANY**
**6595 Walworth Avenue** **Cleveland 2, Ohio**

ENGINEERING YODER MANUFACTURING

**COLD ROLL FORMING MACHINES**
**ROTARY SLITTING LINES**
**PIPE AND TUBE MILLS—Electric Weld**

# Could You Use A 200% Production Increase?

*A 200% Increase?* Sounds incredible, but actually many users of Allis-Chalmers induction heaters report *much greater* production boosts in their brazing, soldering, hardening, annealing, and heating for forging operations.

Increased production is only one of the many profit-building benefits derived from processing with Allis-Chalmers induction heaters. Better product quality, greater uniformity, fewer rejects and less material waste are all part of the remarkable efficiency and economy made possible by this modern equipment.

The Allis-Chalmers induction heater can do your job better, faster and at less cost than your present method. Read what it has accomplished in processes similar to yours:

## SOLDERING

In this operation an Allis-Chalmers induction heater soft solders oil-gauges at the rate of one every two seconds. User reports a production increase of 200% and lower costs.

## ANNEALING

Twenty-four hundred brake arms are annealed every hour on this Allis-Chalmers induction heater. Set-up is automatic, operator merely loads fixture and induction heater does entire job.

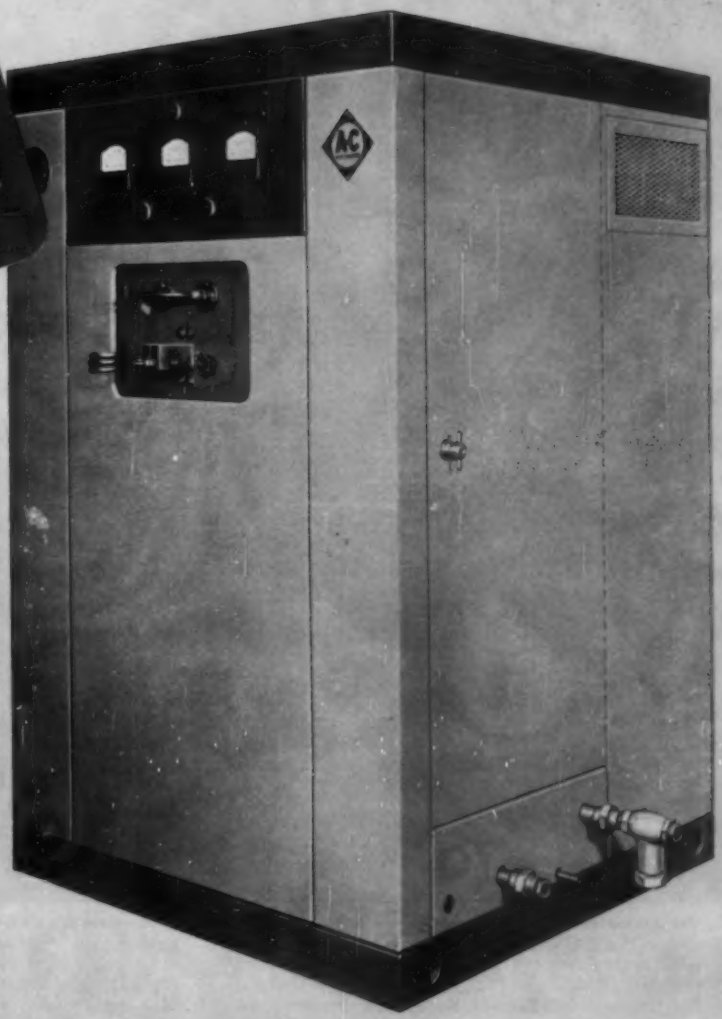
## BRAZING

This job is one of brazing shrouds to blade tips in a turbo-jet assembly. By switching from hand brazing methods to Allis-Chalmers induction heating, *brazing time was cut in half.*

***Ask for Induction Heating Information Packet***

**ALLIS-**

ALLIS-CHALMERS
**Induction HEATER**
10 to 100 KW



- High Production
- Fast Heating
- Low Heat Loss
- Minimum of Rejects
- Positive Control
- Low Maintenance
- High Quality Product
- Easy Cleaning

**NEW 25 Kw Unit** **Air Conditioned**

Air taken in through filter to cool components maintains an internal pressure higher than atmospheric pressure. Contamination of mechanical and electrical parts is prevented by outward seepage of air; maintenance and cleaning are reduced.

**HARDENING**

Here trimmer blades are being hardened at the rate of 2250 per hour with an Allis-Chalmers induction heater (old rate 400). Manufacturer cut costs hardening 14 totally different parts.

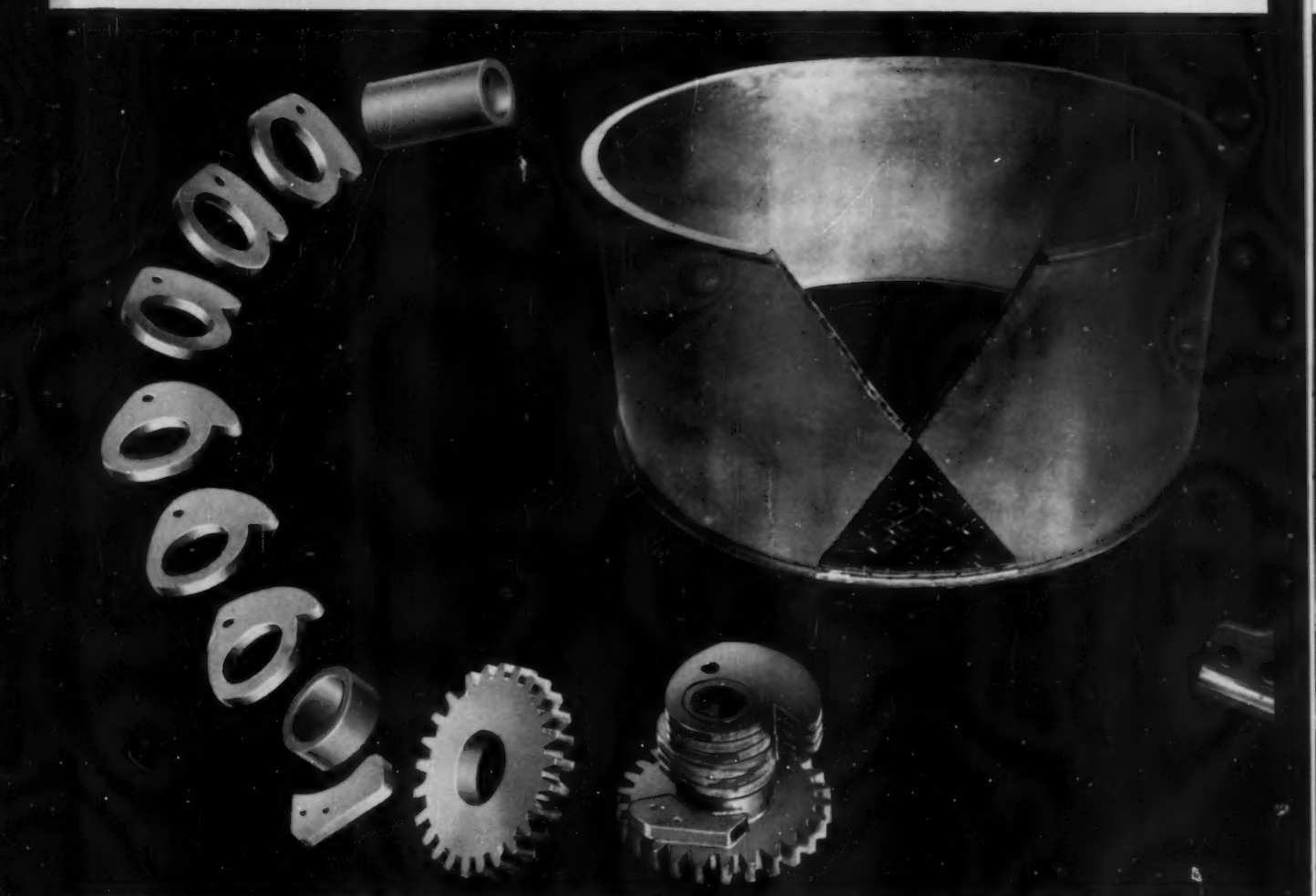
**MELTING—FORGING**

Allis-Chalmers motor generator induction heaters. Ratings, 15 kw to 1250 kw. Three standard frequencies: 960, 3,000, and 10,000. Built with split outer casing for ease in disassembly.

For complete information on units to fit any application requirement, contact your A-C district office or write Allis-Chalmers, Milwaukee 1, Wis.

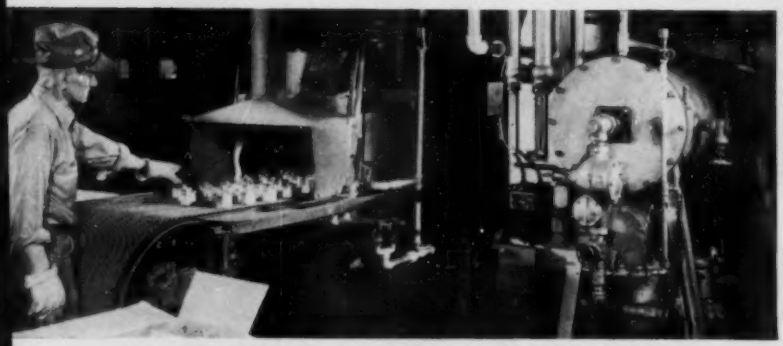
A-5294

**CHALMERS**

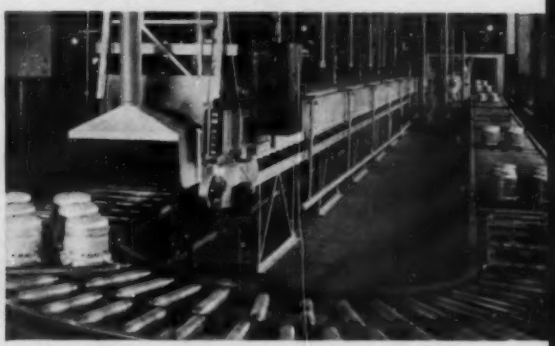


**Versatility of furnace brazing** is shown in these applications. Complex assemblies like the cam-and-gear cluster on the left can be fabricated from punched laminations brazed securely in a General Electric mesh-belt furnace. Required contours are obtained without expensive machining from solid stock.

**Thin sections can be joined to heavy sections** to produce light-weight rigid structures without sacrificing strength or inducing local distortion. Honeycomb structure at top center weighs about one fourth as much as solid assembly of same rigidity. It is typical of design improvements made possible by brazing in General Electric furnaces.



**Continuous production** of small parts in this General Electric mesh-belt furnace is carried out by loading assemblies directly on the belt. Protective atmosphere equipment, at right, eliminates need for flux in most cases, keeps parts clean enough to be passed directly from the furnace, without cleaning or pickling.



**Automatic charging,** and discharging and return conveyors of this General Electric roller-hearth furnace make it almost self-operating, reduces handling costs. G-E roller-hearth furnaces handle heavy assemblies and are well suited for automated lines.

**GENERAL ELECTRIC SELLS A COMPLETE LINE OF HEAT PROCESSING EQUIPMENT**

**FURNACES • METAL-SHEATH • INDUCTION**

Box · Cylindrical Pit · Roller Hearth · Elevator

**Two or more metals can be joined,** as in the bellows housing shown above. The steel flange is furnace-brazed to a brass shell, using preplaced rings of silver brazing alloy. The desirable qualities of each metal are retained.

**Development work** is done in this General Electric box furnace, which could also be used for job-lot production. Low in first cost, General Electric box furnaces need little maintenance.

# Produce Complex Assemblies Faster and at Less Cost with General Electric Furnace Brazing

General Electric furnace brazing speeds production of really "tough" assemblies—and often does it at less cost than you can do it by your present methods.

For example, here are three types of work where you can improve production with furnace brazing.

**You can make complex assemblies** from already formed components, and save both material and machine costs.

**You can make assemblies of two or more different alloys** without changing the desirable characteristics of either.

**You can join thin sections to heavy sections** without sacrificing strength or inducing local distortion.

These characteristics of furnace brazing can be used in a number of widely different production setups. And General Electric's complete line of furnaces and associated equipment lets you pick the proper furnace to introduce furnace brazing into your particular setup—economically, efficiently.

**Cost reductions** are typical with furnace brazing because labor content per assembly goes down while output goes up. Waste is reduced since assemblies can be built up of components instead of being machined from solid stock. Uniformity of results frequently leads to reduced inspection costs.

**Improved products** are the rule with furnace brazing. Life of assemblies is increased because joints have high strength, resist vibration and impact, and are uniformly tight. Assemblies show little or no distortion, since they are free from localized strains. They present a good finished appearance without afterwork because the brazing alloy forms neat fillets. Also protective furnace atmospheres eliminate formation of oxides and do away with the need for flux in most cases.

**Increased production** over other joining methods is possible, since many joints can be brazed simultaneously. Furnace brazing is adaptable to continuous production, with increasing output.

**For a careful analysis** of your furnace brazing needs call your General Electric Heating Specialist. Ask him to show you how you can benefit by using furnace brazing. You can reach him at your local General Electric Apparatus Sales Office. If you prefer, send in coupon below for bulletins describing furnace brazing operations and equipment.

## GENERAL ELECTRIC

**FREE PROCESS BULLETINS**

Section G721-8,
General Electric Company
Schenectady 5, New York

Please send me free bulletins checked below.

**MODERN HEAT PROCESSING BULLETINS**

- ☐ Furnace and Induction Brazing, GEA-5889
- ☐ Protective Atmospheres, GEA-5907

**TECHNICAL BULLETINS**

- ☐ How and Where to Use Furnace Brazing, GEA-3193
- ☐ Electric Furnace Brazing, GER-106
- ☐ Furnace Brazing of Machine Parts, GER-339

NAME.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....

Mesh Belt

Rotary Hearth

Tower

Cylindrical Bell

Metal-sheath

Electronic Induction

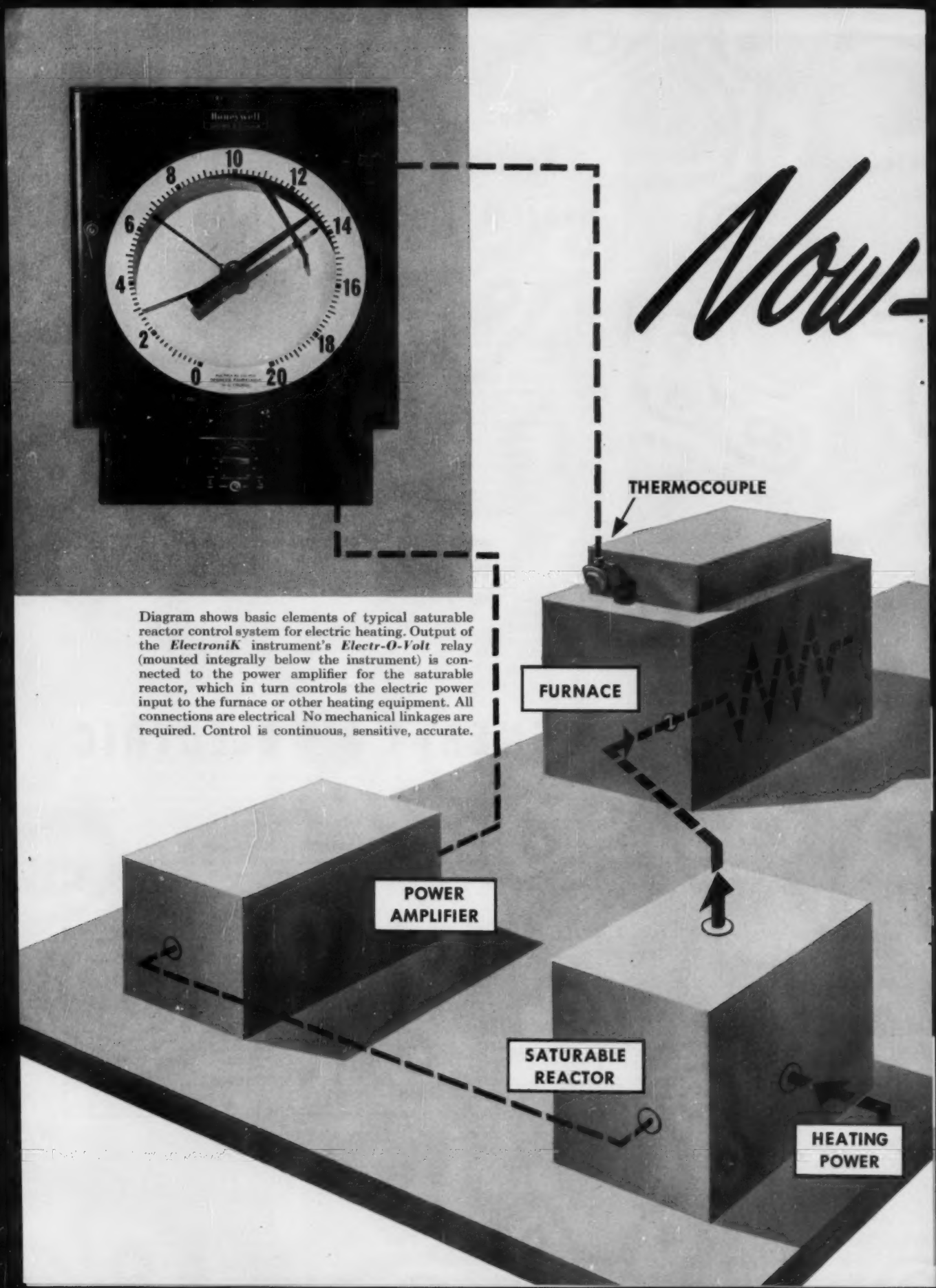



Diagram shows basic elements of typical saturable reactor control system for electric heating. Output of the *ElectroniK* instrument's *Electr-O-Volt* relay (mounted integrally below the instrument) is connected to the power amplifier for the saturable reactor, which in turn controls the electric power input to the furnace or other heating equipment. All connections are electrical No mechanical linkages are required. Control is continuous, sensitive, accurate.

# continuous, accurate control of electrically heated equipment

## *ElectroniK* instrumentation with Electr-O-Volt* relay provides continuous throttling in saturable reactor control systems

You can now regulate temperatures of electrically heated furnaces, ovens, and similar processing equipment within exceptionally close tolerances, by using an advanced *ElectroniK* control system in conjunction with saturable reactors. This type of control eliminates the abrupt surges of power and the expense of contact replacement which are frequently objectionable factors of on-off or pulsed electric control.

***Continuous control action.*** The *Electr-O-Volt* relay, actuated by the *ElectroniK* instrument, provides continuously variable control input to the saturable reactor power amplifier. This arrangement gives true proportional-plus-reset control action, which adjusts heat input to compensate for size of load, ambient temperature and other transient and long-term variations in heat demand.

***Completely electronic.*** The system has no mechanical linkages, contactors, or other complex moving parts. Its high speed and sensitivity give the precise control required by modern processes.

***Broad range of use.*** *ElectroniK* control for saturable reactors is applicable to high-temperature heat-treating furnaces, reaction vessels and many other types of electrically heated equipment. It makes possible smooth, finely-adjusted regulation of electric power at high efficiency.

For a discussion of how this control can be applied to your specific problems, call your local Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

*Trademark

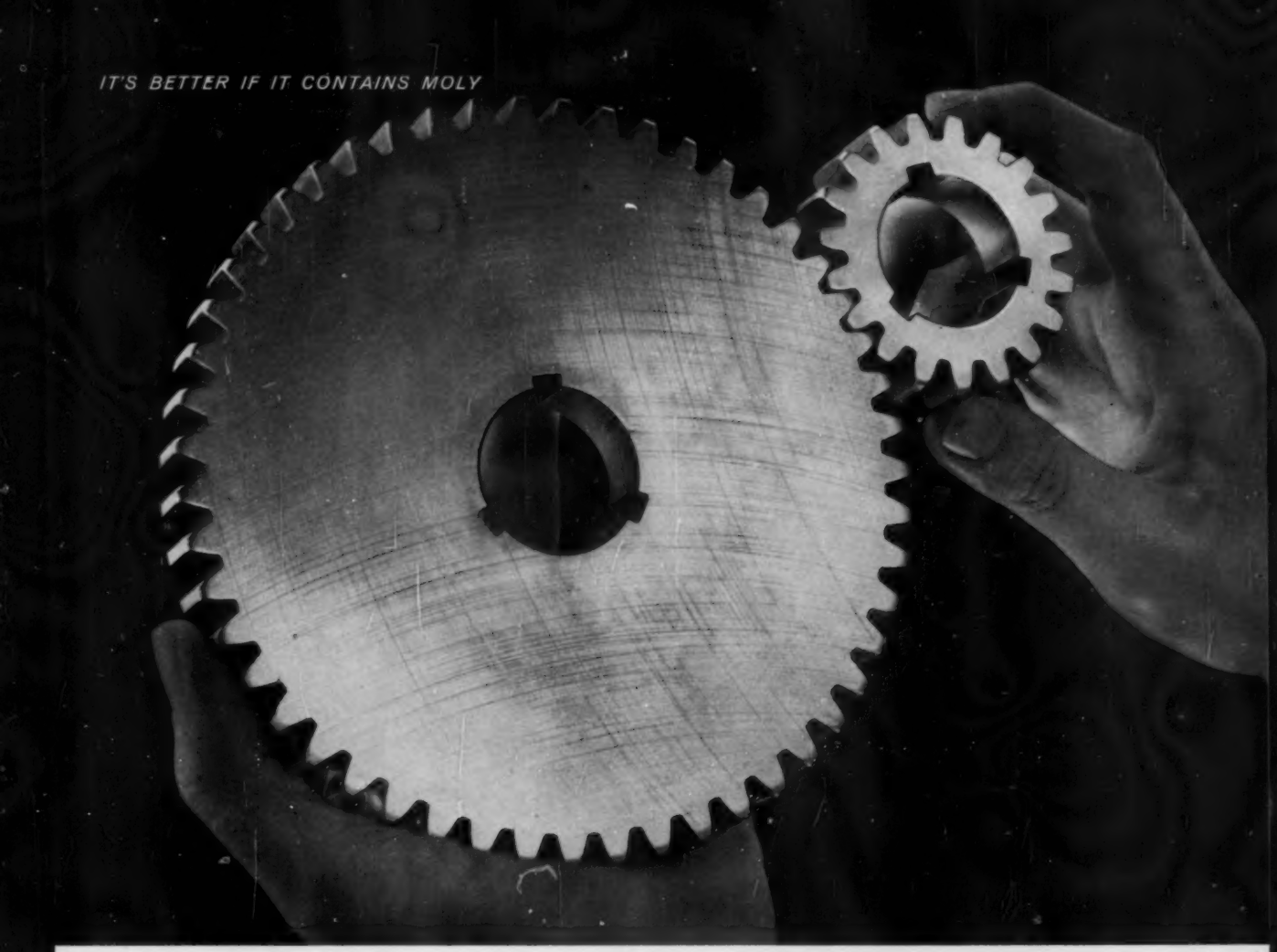
● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers," and for new Bulletin 8420, "*Electr-O-Volt* Relay."

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

*First in Controls*

IT'S BETTER IF IT CONTAINS MOLY



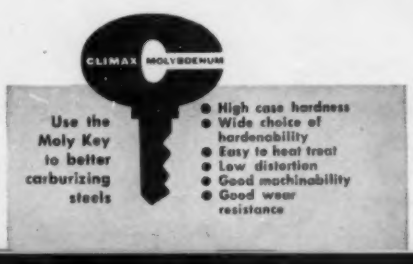
# Up to 1% Moly in carburizing steels gives required hardenability economically

Why limit the use of molybdenum to the .15/.25% Mo and .20/.30% Mo contents of the traditional grades? For the contributions of moly do not stop there. Laboratory tests and production runs prove that as molybdenum contents increase up to 1%, hardness increases progressively. A wide range of case and core hardenabilities, therefore, can be obtained – economically, too.

Tests with a series of molybdenum-manganese steels show that these compositions give higher case hardness on a direct quench than other steels of comparable core hardenability. One extensively tested composition, for example, is 0.5% Mo – 0.5% Mn steel. It shows longer life, and is lower in cost than steels previously used. And it produces a higher case hardness with similar or less distortion. What's more, tool life and surface finish are equal or better. Good reasons why several companies have already adopted this grade for automotive gears and other critical applications.

If you use carburizing steels, see what a higher molybdenum content can do for you. Part of the story is contained in the technical article "New Carburizing Steels For Critical Gearing." For your copy, or other technical data, write Climax Molybdenum Co., Dept. 5, 500 Fifth Avenue, New York 36, N. Y.

**CLIMAX MOLYBDENUM**



# DREVER Salt Bath

for CONTINUOUSLY DESCALING STAINLESS STRIP

descales

The above 35'-0" long Drever Continuous Descaling Bath will descale 18,700 lbs/hour when strip enters bath at bath temperature. Entering strip temperature is controlled by regulation of quenching temperature after strip is discharged from a catenary annealing furnace.

Drever descaling baths are heated by gas-fired immersion tubes with proportioning automatic temperature control.

Other baths are supplied for continuous or batch operation for strip, plate, wire, tubing and other ferrous or non-ferrous products.

*Write for full information...*

DREVER COMPANY

30

# If you machine parts like these...

# we can save you UP TO 30%

## ...with Ryerson leaded steels

If you machine carbon or alloy steels for production or maintenance applications—you should be able to make substantial savings by switching from a standard steel to a Ryerson *leaded* steel.

We can tell you about customers who produce up to 50% more parts per machine hour, now that they have changed over to a leaded steel recommended by Ryerson. Others report tool life lengthened as much as 300%... rejects reduced to all-time lows... machine down-time slashed... finishing processes eliminated.

The nation's largest stocks of leaded steels in a wide range of types and sizes are ready for quick shipment from Ryerson. (See listing below.) Each is the fastest machining steel of its type available anywhere. If you are not now using leaded steels, it will be worth your while to investigate the possibility of adapting one of them, or several, to your operations.

A Ryerson representative will be glad to work with you. Show you dozens of case histories—good hard facts that document just how well Ryerson leaded steels have worked out under actual shop operating conditions. Call your nearby Ryerson plant.

### LEADED STEELS IN STOCK

**CARBON STEEL BARS**

Ledloy (Screw Steel)... Cold drawn rounds, squares, hexagons.

Ryconse (Case Hardening, Low Carbon, Manganese)... Cold finished rounds.

**ALLOY STEEL BARS**

Rycut 20 (Low Carbon, Case Hardening)... Hot rolled and cold finished rounds.

Rycut 40 (Medium Carbon)... Hot rolled and cold finished rounds, annealed to heat treated and stress relieved.

Rycut 47 (Medium Carbon)... Hot rolled, annealed rounds.

New Rycut 50 (Medium Carbon)... Hot rolled and cold finished rounds in annealed condition, hot rolled rounds heat treated and stress relieved.

Leaded 8620... Rounds hot rolled, cold finished.

Leaded 4140... Rounds, cold finished, annealed or heat treated and stress relieved.

Leaded 8647... Rounds, hot rolled, annealed.

**CARBON STEEL PLATES**

New E-Z-Cut Plates (Hot rolled, low carbon, manganese.)

# RYERSON STEEL

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI CLEVELAND • DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Metal Progress
Volume 71, No. 1 January 1957

## Stahl und Eisen

METAL PROGRESS extends heartiest congratulations to *Stahl and Eisen*, the outstanding foreign publication of the basic steel industry, on its 75th birthday. The event was fittingly commemorated with a special issue carrying a large number of handsome multicolor advertisements and, among the usual number of authoritative technical articles, a review of editorial milestones.

When it was founded in July of 1881, the directors of the Verein Deutscher Eisenhüttenleute planned a magazine devoted to the "realistic treatment of economic as well as technical questions relating to the steel industry". It appears noteworthy in 1957 that the philosophy of emphasizing the *technical* as well as the *economic* facts of industry constituted a pioneering approach in those days, even a drastic departure from the accepted thought. Today we feel that the best technical development does not in itself spell progress unless it also proves to be sound economics.

The phenomenal increase in the rate of growth of metallurgical knowledge since grandfather's time is readily apparent from tracing just some

of the more important papers in *Stahl und Eisen* during its infancy:

In 1882 Adolph Ledebur published the first known method of determining oxygen in steel.

Adolph Martens' sketches of microstructures reflected the progress of metallographic work "since 1878".

Drawings of a bessemer converter were made public in an issue during the first year of publication; an openhearth was first described in 1882, a year later.

The original iron-carbon diagram, modifications of which have haunted innumerable generations of examination-fevered metallurgists ever since, can be found in 1900.

Actually the magazine was born of a real need of the times because the men in the German steel industry found themselves without an adequate literary outlet.

The ups and downs of the German nation are mirrored in the growth and struggles of this valiant periodical which carried on its functions through depressions and two World Wars to a point where it now enjoys a readership unprecedented for a German magazine (10,500 subscribers in all principal countries of Europe, the Americas, Africa and the Near East). The scope of the abstracts covering the world's technical literature (over 550 periodicals), the book reviews, especially the "economic panorama", and *Umschau* (critical digests of groups of articles) are features which have made *Stahl und Eisen* unique among technical publications. Not least of the remarkable things about our eminent contemporary is the outstanding excellence of typography, illustration and letter press – the despair of any lover of good printing who attempts to get a good job of work done in the United States. One printer – A. Bagel of Düsseldorf – has done the work since 1881!

What reads like sound advice in these days of complaints that American college graduates cannot express themselves articulately must have been apropos even in 1881 when the following paragraph appeared as part of a guide to authors:

"Some technical writers consider the treatment of a scientific problem in simple terms somewhat degrading and rarely miss an opportunity to endow their brain children with the hallmarks of higher education. However, bombastic mathematical gobbledygook (*formelkram* is the German slang) and numerous integral signs are evil unless they are absolutely necessary. They cause a portion of the readers, especially the busy practical man, to put aside such material immediately or to leaf past the pages. *The skilled treatment of involved problems by simple means is always most effective and successful.*"

The most significant developments, as seen by the editors of *Stahl und Eisen*, are the singular perfection of measuring techniques, the diversification of consumer demands, and the necessity for uniformity and reproducibility in product. At the same time, it is noted that teamwork has now largely replaced the individual effort of 50 to 75 years ago, fostered originally through what they somewhat quaintly call "voluntary compulsion" of the war years, and later engendered by the hard times of the postwar period. Joint authorship of technical papers has become increasingly popular, and industry-wide cooperation in society-sponsored investigational projects is now the rule after long decades of adamant refusal of the large companies to participate or contribute of their own information. Original reports of technical committees now account for about 85% of all their scientific contributions.

It certainly speaks well for the men who initially conceived the idea for *Stahl und Eisen* that even today, after three quarters of a century of publishing, the original policies and goals are still being pursued.

Here's wishing the magazine another three score and fifteen years of successful activity, matching its enviable performance and past leadership!

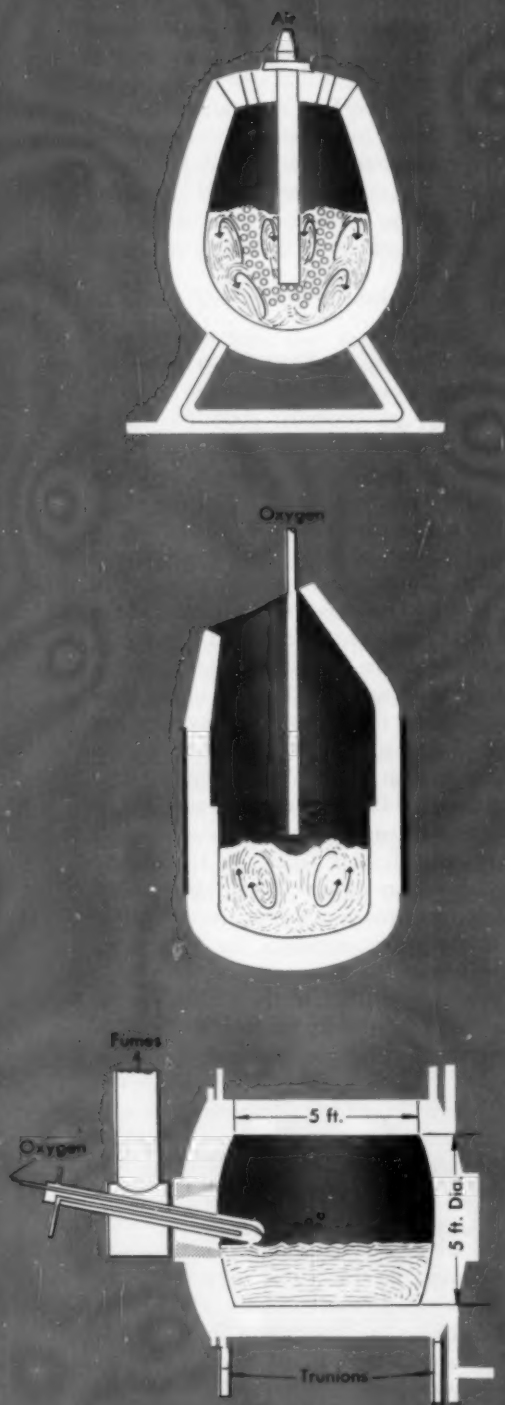



*Fig. 1 – (Top Sketch) Top Blowing as Proposed by Bessemer; (Center) Tilting Vessel of Converter Shape Used for LD-Process at Linz, Austria; (Bottom) Kalling's Rotary Furnace for Purifying Pig Iron*

# Enriched Blast in Basic Steelmaking

*By PIERRE COHEUR* and H. KOSMIDER†*

**Europeans find that the use of oxygen-enriched blast with or without supplementary oxygen through the converter's mouth speeds the steelmaking process, consumes more scrap, utilizes offgrade pig iron, and broadens the applications of the steel produced. (D 3, ST)**

SINCE WE HAVE just completed a century of time since Bessemer obtained his first patent, it might be well to start this article with some citations from his other patents which will show that he had considered steelmaking methods other than the one which has been so universally used – namely, the blowing of air through tuyeres in the bottom of a teapot-shaped vessel lined

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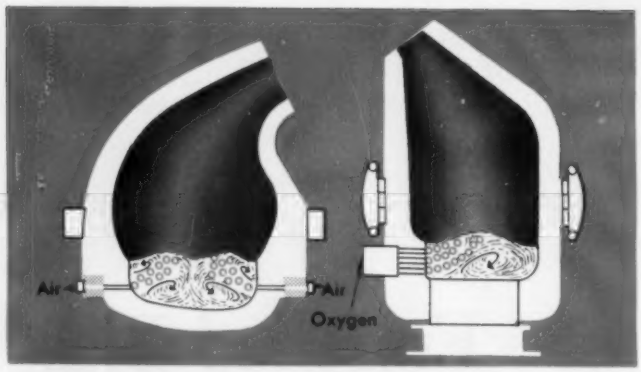


*Fig. 2 – (Left) Side Blown Converter Suggested by Bessemer in 1886; (Right) Submerged Tuyeres in Mannesmann MA-Process Converter*

either with acid (quartzite) or basic refractory (dolomite). In fact, they foreshadow the European developments of the last decade, which have successfully removed some of the disadvantages of converter steel when applied to certain important specialized purposes.

**Top Blowing** – Bessemer's process consists essentially of "blowing a gaseous fluid containing oxygen" into liquid iron. In his first experiments, he pumped air through a vertical pipe into a crucible of molten iron. (The first plant in Sheffield had bottom-blown vessels, as did the first Swedish converter[1] as well as the American furnace of William Kelley, which antedated these events although not patented until later.) A vessel for top blowing with air, as proposed by Bessemer, is shown in the top sketch, Fig. 1, whereas the modern Linz-Donawitz or LD-process[2] has a tilting vessel as sketched in the center, blown with oxygen. Finally, Kalling – at Domnarvet, Sweden – has proposed the rotating furnace shown at the bottom, Fig. 1, a scheme which we understand has been very successful in refining high-phosphorus irons in an experimental way; the furnace itself has been operating for some years for desulphurization.[3] The LD-process, by the way, has been making steel in tonnage in Austria since mid-1953; plants at Dominion Foundries & Steel Co. in Hamilton, Canada, and at McLouth Steel Corp. in Trenton, Mich., have so successfully operated 50-ton vessels that a plant with annual capacity of 300,000 tons is being built by Jones & Laughlin Steel Corp. at Aliquippa, Pa.

**Side Blowing** – Another way of getting a "gaseous fluid containing oxygen" into intimate contact with molten ore is side blowing. This was mentioned by Bessemer in the *Journal* of the Iron and Steel Institute for 1886, and a sketch of the proposal is shown in Fig. 2. This idea has been fairly widely used for 50 years in the steel foundry industry; the Tropenas converter has its tuyeres placed on one side nearly at the top level of the molten iron. Within the last few years, the vessel with submerged tuyeres (Fig. 2 at right) and oxygenated blast has been studied at Mannesmann Rolling Mills at Huckingen, Germany, but we are informed that this so-called MA-process has proven noncommercial, partly because of the heavy erosion of the refractories in the tuyere zone.

Closely allied to this is the "turbohearth" which has been intensively studied by the U.S. Steel Corp. for the last decade.[4] It is a basic converter of 10-ton capacity (Fig. 3). While the published results have looked extremely encouraging – openhearth iron is converted into steel quite low in phosphorus, sulphur and nitrogen – no plant for tonnage operation has yet been built, as far as the present authors know.

**Blowing Into Hearth Furnaces** – Bessemer himself patented the refining by oxygenated gas of iron contained in a hearth furnace, as is proven in Fig. 4 from his original patent in 1855. Another sketch shows the cross section of a reverberatory furnace with the blast piped through the side wall and impinging on the surface of the bath. The modern version of this idea is the openhearth (or electric) furnace with the auxiliary

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[1] "The First Successful Bessemer Steel", by Karl Fredrik Goransson, *Metal Progress*, January 1956, p. 85.

[2] "LD-Process of Steelmaking With Oxygen Jet", by Herbert Trenkler and H. F. Hauttmann, *Metal Progress*, January 1956, p. 49.

[3] "New Manufacturing Processes for High-Grade Steel in Sweden", by Bo Kalling, *Metal Progress*, January 1954, p. 108.

[4] "Turbo-Hearth Process Promises Quality Steel in 12 Minutes", by C. E. Sims and F. L. Toy, *Steel*, Feb. 27, 1950, p. 72. Also "Steelmaking Processes; Some Future Prospects", by C. D. King, *Journal of Metals*, April 1954, p. 455.

oxygen jet, primarily to hasten the melting of scrap or the decarbonization (Fig. 5). It would seem that, in all fairness, processes which inject oxygen into openhearth furnaces should be named after their inventor – Bessemer.

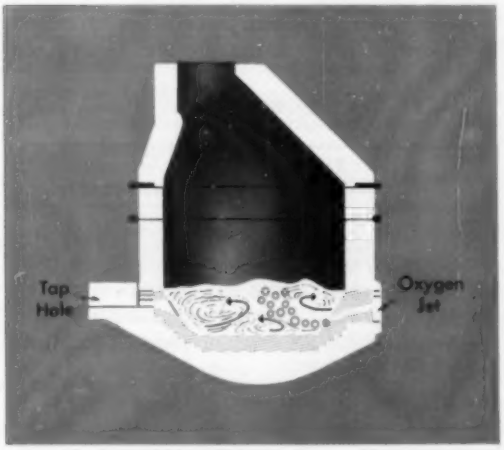
**Combinations** – A final possibility, which will be discussed in some detail later in this article is bottom blowing with additional oxygen lancing above the bath, whereby the CO and $H_2$ from the reaction are completely oxidized, thus gaining much additional heat *within* the vessel.

### Bessemer Versus Openhearth

From the above very rapid review, it will be seen that European experiments and processes directed primarily toward improving the basic bessemer process (we call it the Thomas process) have considerably wider application and have in fact attracted the earnest attention of the American steel industry which, as is well known, is based on the product of the openhearth furnace.

Perhaps it is suitable at this point to remind the reader that the refining reactions in the hearth furnace and the pneumatic vessels are essentially the same. Carbon, silicon, manganese and phosphorus are converted to the oxides and bubble out or slag off. Since carbon is the major element to be eliminated, the speed of the oxidation process is governed mainly by the rate of decarburization, and this in turn is governed almost entirely by the rate of oxygen supply and by the bath temperature. Much of the oxygen in openhearth refining comes from ore in the charge; this results in a thermal deficit even though the charge is comparatively high in silicon, phosphorus and carbon. On the other hand, oxygen from air in pneumatic processes results in a large gain, the oxygen is supplied at a vastly higher rate, and the reactions are completed in minutes rather than hours.

*Fig. 3 – Cross Section of Turbohearth*



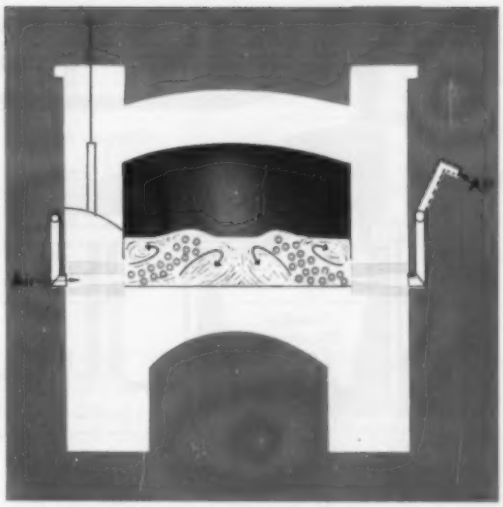



*Fig. 4 – Bessemer's Proposal for Injecting Oxidizing Gas Mixture Into a Hearth Furnace*

There is small reason for us to rehearse the well-known reasons for this difference in practice on the two continents. Suffice it to say that the American openhearth furnace is favored by the low-phosphorus iron ores, abundance of oil and natural gas fuels, and large amounts of demolition scrap. Bessemer steel, either from acid or basic-lined vessels, is acknowledged to be excellent for structural shapes, concrete reinforcement, screw stock, transformer sheet, and wire. In Europe, the Thomas process is admirably adapted to our high-phosphorus ores – producing as it does an exceedingly valuable fertilizer as by-product – and to our considerably smaller scale of steel production in smaller plants. We have found by many years of experience that it also has properties which are specially valuable in such applications as railroad rails, thick sheet and plates, and some springs. On the debit side are high nitrogen from the air blast, and high phosphorus primarily due to our high-phosphorus ores rather than the steel refining process. Consult the analyses in Table I representing averages in Belgian and Luxembourg steel plants and in American openhearth practice.

This high content of nitrogen and phosphorus must not be regarded as an intrinsic defect of the process, but simply as a limitation of its field of application. Since ordinary Thomas steel has proven satisfactory for many major uses,

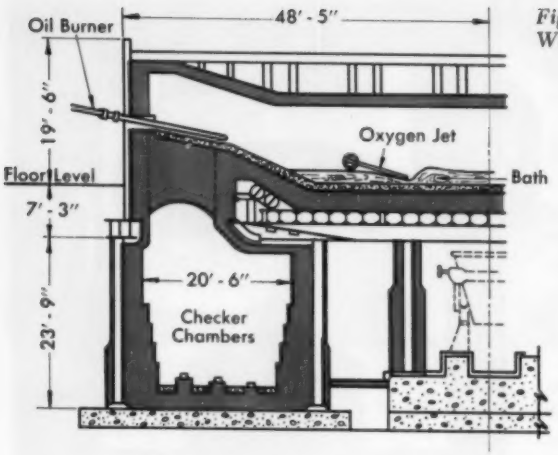



*Fig. 5 – Modern Openhearth With Auxiliary Oxygen Jet*

there would be no advantage in modifying the steels obtained in the converter by the conventional method. It is no less certain, however, that for some applications requiring a high degree of ductility at room temperature, such as sheets for cold rolling and deep drawing, the usual rimmed basic bessemer steel is handicapped by its nitrogen and phosphorus content.

This is the very reason why new manufacturing processes have been developed in Europe over the last half-century.

### Oxygen in Bottom Blow

Obviously the simplest way to reduce nitrogen in blown steel is to reduce the partial pressure of nitrogen in the blast either by enriching the air in oxygen or by diluting it with steam or some gas free of nitrogen. In oxygen enrichment the reactions will obviously be speeded and temperatures increased; on the other hand, dilution may not be so great as to reduce the reaction rate and temperature unduly.

Let us first look at the use of supplementary oxygen. On the economic side it increases the rate of refining and hence the output per converter; it permits more scrap to be charged; and permits the use of pig iron of abnormal chemical composition which heretofore was either difficult or impossible to blow with atmospheric air. For example, a 30-ton vessel which requires about 15 min. for conversion of normal pig iron with atmospheric air (2% $O_2$) can refine the same amount of metal in 10.5 to 11 min. if the air is enriched to 30% $O_2$ – an increase of 25% in production rate. Rates are increased 20% in 50-ton vessels blown with 27% $O_2$ blast. We therefore find that an expedient used to improve certain qualities in the product (low nitrogen) also increases the production rate.

This more rapid elimination of carbon by an increased rate of oxygen supply is accompanied by so rapid an increase in temperature that scrap must be charged to keep it down. In the instances cited about 5 tons of scrap can be melted in the 30-ton converter and 8 tons in the 50-ton converter. As much as 25% of the product comes from scrap iron in large converters with more highly enriched air. Thus the practice is as adaptable to existing scrap supply and relative cost as is the openhearth process. Temperature can also be kept under control by adding ore and limestone.

The heat generating power of the various oxidizable elements in pig iron – phosphorus, silicon, manganese and carbon – has been worked out[5] for various percentages of oxygen in an oxygen-nitrogen mixture and this enables

**Table I – Representative Analyses of Irons and Steels**

| Element | European Basic Bessemer | American Openhearth |
|---|---|---|
| Pig iron | | |
| C | 3.60 to 3.90% | 4.10 to 4.40% |
| P | 1.50 to 2.10 | 0.10 to 0.90 |
| S | 0.040 to 0.080 | <0.050 |
| Mn | 0.4 to 1.2 | 0.4 to 2.0 |
| Si | 0.3 to 0.6 | 0.5 to 1.5 |
| Steel (ladle analysis) | | |
| $N_2$ | 0.0090 to 0.0120 | 0.0030 to 0.0060 |
| P | 0.045± | 0.010 to 0.030 |
| S | 0.035± | 0.025 to 0.040 |

[5]"Evaluation of the Economics of Materials in the Basic Bessemer Process With the Aid of Energy-Balance Computations", by E. Senfter, G. Schnuch and G. Guthmann, *Stahl und Eisen*, March 29, 1951, p. 334.

**Table II – Analysis of Basic Bessemer Steels**

| Process | Nitrogen | | Phosphorus | | Sulphur | |
|---|---|---|---|---|---|---|
| | Mean | Deviation | Mean | Deviation | Mean | Deviation |
| Atmospheric air blast | 0.0090-0.0120 | 0.0025 | 0.045 | 0.012 | 0.035 | 0.007 |
| Enriched air with: | | | | | | |
| 1. Scrap additions | 0.0080 | 0.0015 | 0.045 | 0.012 | 0.035 | 0.007 |
| 2. Scrap, ore and limestone | 0.0060 | 0.0012 | 0.035 | 0.007 | 0.025 | 0.005 |
| 3. Ore and limestone | 0.0050 | 0.0010 | 0.025 | 0.006 | 0.020 | 0.005 |
| OV (oxygen-steam) | 0.0025 | 0.0005 | 0.020 | 0.006 | 0.020 | 0.005 |

us not only to calculate the amount of auxiliary charge in regular practice but also to determine in advance the proper conditions for refining off-analysis irons. These calculations have been confirmed in plant practice.

For example we may take an experimental run at the Kloeckner Works, where we used an oxygen-enriched blast, and a standard open-hearth pig iron. The amount of scrap added to cool the charge was about 10% – a little lower than we calculated theoretically – partly because the temperature of the pig iron was definitely lower than that assumed in our calculations, which corresponded to the temperatures obtained in the Liège steelworks.

Many more such citations could be made leading to conclusions which, in our opinion, seem extremely important:

First, they extend blast-refining to openhearth pig irons, for which it was not originally intended.

Second, the conditions existing in the blast furnace may be modified so as to produce, in case of need, steels of smaller chemical heat-producing capacity than those under normal conditions. Thus there would be no point in returning basic converter slag to blast furnaces merely to increase the phosphorus concentration of the pig.

The obvious conclusion is that, when working out the economic balance-sheet for the production of steel, attention should be extended to the whole steelworks and in particular to the supply of raw materials.

### Analysis of Steel

It may be remarked that the blast enrichment program, as well as the cooling additions, may be varied within rather wide limits. The blast can be simply enriched in oxygen, and the resulting increase in bath temperature neutralized by supplementary additions of scrap, ore or limestone, or combinations thereof. There is a practical limit in this direction; above an enrichment to 40% $O_2$ blowing time is too short and bottom life is impaired.

An alternative is to cut off the blast and replace it either with a mixture of oxygen and a gas free of nitrogen, or with oxygen and superheated steam. The last method is certainly the most drastic.

Applied industrially in Belgium, Luxembourg and Germany, some of these various methods of blowing have given steels whose analyses are shown by Table II. In all of them the nitrogen content of the steel is quite substantially reduced. Note particularly the results with oxygen-enriched blast with addition of ore and limestone, and also the OV (oxygen-steam) process. The latter yields steel with lower nitrogen contents than current openhearth steels.

Furthermore, when blowing with oxygen plus steam there are no brown fumes, and this avoids the necessity of gas-cleaning equipment.

If phosphorus is still too high for some specialized application, it can be reduced to around 0.02% by skimming the converter near the end of the blow and making up a second slag.

Thus it appears that it is now possible, when necessary, to produce converter steels having nitrogen, phosphorus and sulphur very close to, and even lower than, the contents usually found in openhearth steel with which it is customary to compare them. The same may be said for the carbon, manganese and oxygen, which can be adjusted in both processes to similar levels.

### Oxygen-Steam Blow

Probably the least orthodox of these new methods is the blowing of iron with oxygen-steam mixtures. We can cite a campaign at Kloeckner works with 20 blows of about 22 tons each. The pig iron analyzed 4.2% C, 1.0% Mn, 0.35% P, 0.65% Si and 0.035% S. The mixture contained 45% $O_2$, 55% steam by volume; 75 cu. m. (2650 cu.ft.) of oxygen per metric ton (1 metric ton = 1.1 short ton of 2000 lb.). Charged with the iron

were also 1.6 metric tons lime and 0.75 metric ton of scrap. Average time of conversion was 7.5 min. and yield of steel was 87.2%. Its finishing temperature was 3000° F. and its analysis (single slag process) was 0.046% C, 0.25% Mn, 0.019% P, 0.016% S and 0.0035% $N_2$. This matches the American openhearth process.

**Bottom Blow and Top Oxygen**

Despite the above-mentioned advantages, bottom blowing may not give enough heat to melt the available cheap scrap. This situation may be helped by increasing the temperature in the upper part of the vessel by oxidizing the CO and $H_2$ boiling up from the metal bath – gases which indeed have a high calorific value. They contain, during the decarburization period, 30 to 40% CO when blowing with ordinary air; 50 to 60% CO when the blast is enriched to 35% $O_2$, and 90% $CO + H_2$ when blowing with $O_2 + H_2O$.

Now if 95% $O_2$ be piped down into the vessel, every cubic meter, combining with CO or $H_2$, theoretically will supply 6000 calories of heat and melt 14 kg. (31 lb.) more scrap.

Practically, we found the figure to be 10 to 12 kg. (22 to 26 lb.) when injecting oxygen into 17-ton converters at a rate of 20 cu. m. per min. The pressure has been chosen so the oxygen does not come into contact with the metallic bath, and is used only to burn the CO or $H_2$ of the gas. In this manner we increased the quantity of scrap consumed by 70 kg. per ton of the iron produced – a 7% gain. This does not represent the possible maximum obtainable.

The slag shapes a little earlier, its temperature is higher but the chemical analyses of slag and steel seem to remain the same as in the normal process, even if we increase the pressure of the oxygen of the lance to oxidize a certain amount of metallics in the bath.

Lastly, let us point out the fact that oxygen blown by the lance does not come into contact with the liquid metal and consequently, does not produce brown fumes.

**Mechanical Properties**

The question now arises as to whether the steel made by these pneumatic processes has mechanical properties comparable with those of openhearth steel – an answer given in numerous recent publications.

According to American, Austrian, German, French and Swedish workers, their properties are equal to openhearth, if not better. Thus, according to Sims and Toy[4] the turbohearth steels made at the South Chicago Works of U.S. Steel Corp. have standard mechanical properties, with bending, elastic, aging characteristics and transition temperatures similar to those of openhearth steels of almost the same composition.

Hauttmann[2] who has specially studied the question, has shown that the steels produced at Linz by top blowing have the standard mechanical properties, cold ductility and toughness. In addition, the steels exhibit a resistance to corrosion in general and to intergranular corrosion in particular, resistance to aging and a fatigue strength as well as welding properties that are similar if not superior to those of openhearth steels of the same composition.

In Belgium, Luxembourg and Germany, the present authors have also made many tests in our laboratories and at our customers' works to check the ductility and weldability of the steel, and we found that, for chemical analyses which are equal or close, basic converter steel is as good as openhearth steel.

There thus appears to be sufficient experimental evidence to show that steels produced by these two differing processes – pneumatic and the conventional openhearth – are mechanically similar.

**Conclusion**

In fine, we believe that steels made by conventional European practices are quite suitable for many, many tonnage applications. For the more specialized uses requiring high ductility, formability, and stability (nonaging) basic steel blown with oxygen or oxygen-enriched blast, in any of several converter modifications, will serve equally as well as openhearth steel of the same analysis. There is no especial virtue residing in the latter process.

From an economic point of view, the new methods of blowing permit a better gearing of steel plant to market and raw material conditions:

1. Those in charge of the separate divisions of a steel plant can regulate the relative quantities of pig iron, scrap and ore consumed and converted into steel.

2. Those in charge of the steel plant as a whole are able to select the most satisfactory burdens for blast furnaces.

3. Finally, iron normally sent to openhearth furnaces can be refined in converters.

Such factors have already become effective in the design of European steel plants recently completed or now under construction.

*Stoves and Gas Mains Frame a Glimpse of an Indian Blast Furnace*

# Expansion of Steel Industry in India

*By V. S. SWAMINATHAN*

**Nearly a billion dollars has been allocated to expand Indian steel production from the present 1,300,000 tons to 5,500,000 by 1961. The privately owned Tata and Indian Iron & Steel Companies are financing 1,100,000 tons of this expansion. Three new ones, each of 1,000,000 ingot tons capacity will be run by the Government; one will be built by the Russians, one by West Germans, and one by the English. (A 4, D general, ST)**

THE EXPANSION of the iron and steel industry has the highest priority under the new (second) Indian Five-Year Plan, "since the levels of production of these materials determine the tempo of progress of the economy as a whole. Steel can be made in India," it is officially said, "at costs which are low in comparison with those of most other countries." During the period of this second plan (1956 to 1961), the Indian Government proposes to raise steel production from 1,300,000 to 5,500,000 tons a year, at a cost of about Rs. 4,700,000,000 (about $925,000,000). Of this, $23,000,000 is set aside for doubling the capacity of the existing plants of Tata Iron and Steel Co. (TISCO) and the Indian Iron and Steel Co. (IISCO), and the balance for building three entirely new Government-owned steel plants. Their location is shown on Fig. 1.

These three new plants are to be built with technical help from different nations – from West Germany at Rourkela, from Russia at Bhilai, and from Britain at Durgapur. Each is planned to make about one million ingot tons of steel, and the estimated cost is about $250,000,000 at

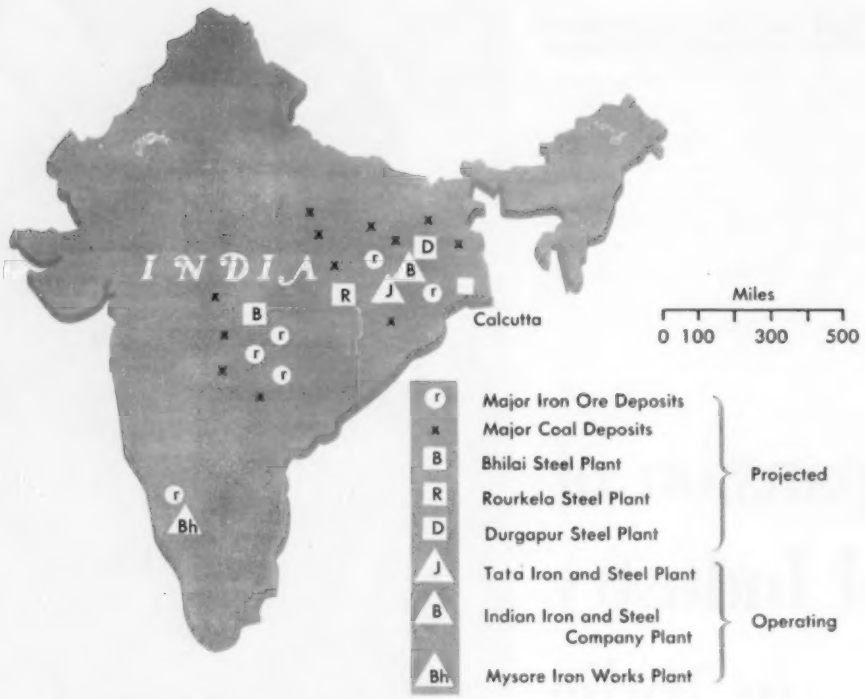



*Fig. 1 — Sketch Map of India Showing Existing and Future Steel Plants and Location of Principal Iron and Coal Deposits*

Rourkela, about $215,000,000 at Bhilai, and about $225,000,000 at Durgapur.

Although the final plants will be similar in ingot capacity, their backgrounds differ significantly, and reflect the trends in India's industrial policy over the past few years.

**New Rourkela Plant**

Rourkela was originally planned on a fairly modest scale as a joint venture of State and private enterprise. In December of 1953 Hindustan Steel Ltd., was formed and capital of $100,000,000 was advanced by the Government of India and the German Indiengemeinschaft Krupp Demag in the ratio of four shares to one. There were eight Indian directors and two German. The German combine will thus be associated in the operation of the plant (whereas in the other two projects the responsibility of the foreign contractors ceases on completion, whereupon the plant will be operated by the Indian Ministry of Iron and Steel). This first project was also the only one put up originally for competitive bidding; the other two agreements are both for "package deals". The Rourkela project was slower in getting started than the other two — for one reason, the Indian Government decided to double the output (initially 500,000 ingot tons) — so the final project was not submitted until March of 1956.

The final plan provides for three batteries of 78 coke ovens, each to consume 1,600,000 tons of coal yearly; three blast furnaces (later to be increased to four) with 1000 tons daily output; a steelmaking shop employing mainly the Austrian LD top-blown converter and oxygen blast; and large hot strip and cold strip mills. The plant will turn out about 720,000 tons of finished flat products yearly, including tin plate and galvanized sheets. It is hoped that the first blast furnace will be producing iron in October 1958, and the whole plant, including the strip mills, will be ready for production at the end of the following year.

Although earthwork has been in progress for some time, at the date of writing (September 1956) the first brick has yet to be laid and all necessary contracts have not yet been let. The first invitations for tenders had a disappointing result. Only one bid was received for blast furnaces; it was from the German Güte-Hoffnungs Hütte. Eight were received for coke ovens, from which a final selection has not yet been made. The Indian Government has recently modified the terms and accepted a single

*Fig. 2 – Converter Shop at Jamshedpur*

joint bid from a German combine – Krupp, Demag, Sack, Stemag, and Schloemann – for the rolling mill. Krupp and Demag have been invited to bid in closed competition for the steel-melting shop.

The heavy backlog of orders now held by German engineering companies may make it difficult to meet early delivery dates. Contracts may therefore have to be divided among a larger number of companies than originally intended. The three 1000-ton blast furnaces, valued at $22,500,000, are to go to Güte-Hoffnung.

The principal suppliers for the $25,000,000 to $28,000,000 steel mill will most likely be Krupp and Demag. Terms of payment, already accepted by Krupp, include up to 30% paid in shares of the Hindustani Steel Corp., 50% cash on delivery, 10% three months later and the last 10% within two years after delivery. As noted, the Austrian oxygen steel process, described in *Metal Progress* in its last annual review of international progress in metallurgy, will be used; royalty fees will be payable to Brassert Technology, which owns the patents. Contracts valued at $70,000,000 to $85,000,000 for the rolling mills may be split among Demag, Schloemann, Sack and Siemag, with Demag probably responsible for the showpiece of the works, the $40,000,000 continuous wide strip mill. Coking installations will almost certainly be built by C. Otto & Co.

**Russians to Build at Bhilai**

By comparison, negotiations for the Russian and British steel projects, though tough, were brief. Negotiation with a Russian team began in November 1954, and an agreement for technical and economic help was signed three months later. A site was chosen at Bhilai on the Calcutta-Bombay main railway line, 180 miles further west from Rourkela, and a detailed project report was submitted by the Russians in December 1955.

An agreement for supply of equipment was signed in New Delhi a few weeks ago. The construction and operation of the works is a project of the Indian Government, but a Russian chief engineer will be in charge of the installation of the plant and its operation in the initial stages. The Russian export agency, called Techno-Export is supplying equipment to a total value of $110,000,000, repayable over 12 years from completion of the works with 2.5% interest.

The plant will have three batteries of 65 coke ovens each and three blast furnaces, each of 1135 tons daily capacity. Steel will be made by the openhearth process. The plant is planned for an output of 770,000 tons of heavy and medium products, including railroad rails and ties, structural shapes, merchant bars, and billets. It is hoped to have two coke oven batteries, two blast furnaces, two openhearth furnaces and a blooming mill in operation at the end of 1958 and to complete the plant a year later.

**British to Build in West Bengal**

The British project originated in a Colombo Plan survey team led by Sir Eric Coates in 1955, which recommended the site for a steel works at Durgapur in West Bengal, 110 miles from Calcutta on the main railway line to Delhi. A consortium of firms called the Indian Steelworks Construction Co. was formed in London with Sir Cyril Jones as chairman and submitted estimates to the Indian Government. After hard bargaining, a "broad agreement" was reached in February 1956 and final specifications were signed in June.

The contract is claimed to be the largest ever placed with a British company. Unlike the Russian plant at Bhilai, the British contractors will erect the entire plant and not merely supply and install the equipment. The total cost of the plant as exported from Britain will be about $140,000,000 while the remaining $85,000,000

represents work that is to be done in India.

The founder members of the British consortium are Simon-Carves, Ltd. (coke ovens); Head, Wrightson & Co. Ltd. (blast furnaces); Wellman Smith Owen Engineering Corp. Ltd. (melting shop); and Davey & United Engineering Co. (rolling mills). Suppliers of structural steelwork represented on the consortium are Joseph Parks & Son, Dorman Long, Sir William Brook Co., and Cleveland Bridge and Engineering. The electrical suppliers will be British Thomson-Houston Co. Ltd., English Electric Co. Ltd., General Electric Co. Ltd., and Metropolitan-Vickers Electrical Co., Ltd. The civil engineering work will be undertaken by the Cementation Co., Ltd.

The proposals plan for three batteries of 78 coke ovens each, three blast furnaces, each to make 1250 tons of pig iron a day, and three open-hearths. The plant will make about 790,000 tons a year of medium and light steel sections, billets, and railway wheels and axles.

There is widespread satisfaction with the technical aspects of the British deal, although the credit terms offered have been a target for criticism. The offer of credit of $32,000,000 by a syndicate of British banks at 1% above the prevailing bank rate, and of $42,000,000 by the British Government at borrowing rate plus small administration charge, falls short of the Russian noncapitalistic terms.

**Expansion of Existing Capacity**

The publicity given to the rival State steel ventures has obscured the contributions being made by private enterprise. Tata Iron and Steel Co., which started a $50,000,000 expansion plan for its Jamshedpur plant in 1953, concluded an agreement last year with the Henry J. Kaiser organization of America for technical help in a further $120,000,000 project intended to raise its annual output to 2,000,000 ingot tons (1,500,000 of finished product) by May 1958.

Cash for this private project has been given priority by the Indian Government. Orders for equipment have already been placed in America, Germany and Japan. The World Bank has approved a loan of $75,000,000 in various currencies to the Tata Iron and Steel Co. to assist in the financing. This is the largest loan the bank has yet made for industry, and the largest the bank has made in Asia for any purpose. First National City Bank of New York, Irving Trust Co., and Manufacturers Trust Co. are participating in the loan to a total of $2,355,000. The first maturity on this will be due in December of 1959.

Germans have also recently secured other private contracts with Tata for equipment rounding out present installations and increasing annual capacity by 800,000 tons. Completion is expected in May 1958 and the cost is estimated at $125,000,000. Orders secured include a continuous billeting mill by Demag ($5,000,000), a cogging mill by Schloemann, a rolling train for sections by Sack, a sintering plant by Lurgi, a coking battery by Didier, and necessary structural steel for the buildings by Ferrostaal.

Indian steel output, at present 1,400,000 tons a year, is thus to rise to 5,500,000 tons by 1961, according to Mr. Ingar, Under-Secretary of State at the Ministry of Industry, during his stay in London on an economic mission. Simultaneously the Indian Iron and Steel Co. is expanding production at its Burnpore and Kulti plants from 300,000 tons of ingot steel and 140,000 tons of pig iron to 700,000 and 400,000 tons, respectively, by 1957. Contracts have been placed, mostly in West Germany and Britain, the total expenditure planned being $60,000,000, about half loaned by the International Bank and the other half contributed by the Indian Government and the company itself.

Thus at the end of the second Five-Year Plan the two private steelmakers are likely to be manufacturing fully half the Indian output of finished steel. Indian economic planning, however, has long placed the iron and steel industry in the "public sector", and there is nervousness in the private firms that sooner or later, in spite of assurances to the contrary, they will be nationalized. However, both have been encouraged by the Indian Government to issue new shares to finance their expansions, which seems to imply some guarantee for the immediate future.

Indian planners are already looking forward to a target of 18,000,000 ingot tons at the end of the third Five-Year Plan in 1966. What remains to be proved is the possibility of carrying out these ambitious objectives within such a short period. New iron ore deposits must be opened to supply even the new plants of the second plan with 6,000,000 tons of ore yearly; coal production must be raised from some 38,000,000 to 60,000,000 tons a year in an industry which quite possibly will be nationalized; hundreds of miles of new railway track must be laid; and some 1200 skilled engineers and 10,000 semi-skilled workers must be trained – the former sent to Russia, Germany and Britain.

# Development of the Aluminum Industry in Austria

By EDUARD NACHTIGALL*

**Now that Austria has regained control of her aluminum industry, several special products for consumers have been devised, including siding and roofing, snow fences, electrical conductors, nails and deep drawing sheet.**
**(A 4, T general, Al)**

THE CURRENT CIVILIAN DEMAND for hydro-electric power from plants in the Austrian Alps has prevented the fullest utilization of available aluminum reduction capacity in our country. The latter may be summarized thus:

The aluminum smelter in Lind, near Salsburg, which is part of the Swiss Aluminium Industrie A.G., was built in 1898, and has an annual output of 6000 tons. Extensive plants in Ranshofen, built during the last War and administered by the Austrian Government, produced approximately 55,000 tons of virgin ingot in 1955.

The steadily increasing demand for aluminum led to the establishment in 1950 of a plant for semifinished products. This is a division of Osterreichische Metallwerke A.G. in Ranshofen. Until that time practically no aluminum was used commercially in Austria, primarily because of competition from the highly developed steel and brass industries. Moreover, a plant for semi-finished products serving the aircraft industry was lost, due to postwar consequences.

Actually, therefore, our aluminum industry lay dormant until six years ago, but in these recent years a number of interesting applications and developments for light metals have occurred.

The manufacturers of semifinished products made 22,000 tons of rolled and forged items in 1955. Of this tonnage about 6000 tons was exported and 16,000 tons remained for domestic consumption, distributed as follows among the different industries:

| | |
|---|---|
| Major electric appliances | 38% |
| Transportation industry | 3 |
| Building trades and architectural | 8 |
| Packaging and containers | 20 |
| Tools and implements | 10 |
| Machinery | 4 |
| Household appliances | 5 |
| Others | 12 |

The large share of the electrical industry is due to the development of hydro-electric power and the expansion of rural and railroad electrification in Austria.

The building trades make use of 2 S, 3 S and 4 S sheet, primarily for roofing, and more than 600,000 sq.yd. have thus far been used for that purpose. For long spans between trusses Dr. Makulan has developed a special guy wire fastening to the purlins. Stamped fasteners are securely clamped to parallel steel ropes, and the preformed aluminum is then rolled out on top of this assembly as shown in Fig. 1. Other prefabricated roofing elements made of aluminum are the ribbed rectangular "Prefa" plate, and the square (rabbeted) "Alufa" sheet. The latter has

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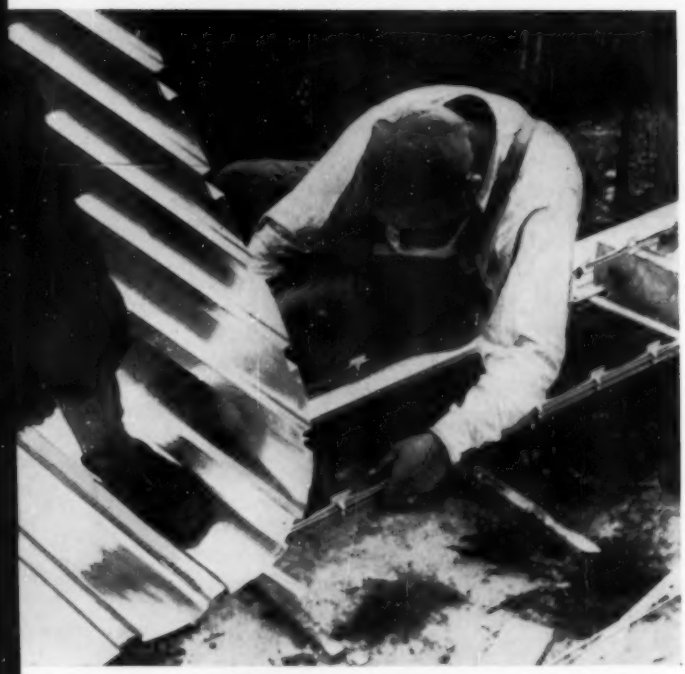


*Fig. 1 – Furring Strip Being Rolled Out on Steel Cable Purlins and Held Down by Properly Spaced Fingers or Clamps*

a double crimp and a notched tab which is nailed to the wooden beam, after which it is joined to the next plate, forming a watertight joint at the fluting.

A new light-metal roof construction has also been developed by Wagner-Biro Inc. of Graz which satisfies all demands concerning strength, light weight, density, insulation and durability. In this type of construction plates are inserted into frame joists made of strong sheet metal profiles, covered by insulation and then topped with rolls of furring strip.

From a number of construction projects now in progress, two may be selected as being especially representative. The cupola of the Urania Observatory in Vienna, destroyed during the war, is being replaced by a rotating hemisphere of 3-mm. gage 52 S sheet supported by 51 S profiles. It provides a new landmark for the city. In the suburbs of Vienna a number of large greenhouses are under construction; the hall-like buildings each cover an area of roughly 30 × 200 ft. The unit being used is a triangular channel-type sheet metal profile 3.12 × 1.75 in. in size made of 3-mm. gage 57 S sheet, and a flat strip of the same material. Between them the glass panels are fastened, separated from contact with metal by rubber sandwiches, thus providing insulation (Fig. 2).

The chemical industry, which is constantly faced with serious materials problems, has readily recognized the physical and chemical advantages of aluminum. High-purity aluminum is extensively used as an insulating lining for sulphuric acid processing and ammonium sulphate vaporizing appartaus. High-purity aluminum piping also finds application in the cellulose and papermaking industries for handling hot sulphuric acid vapor.

A major field for profitable use of aluminum is river shipping. The superstructures of passenger ships are completely built from semifinished products. Aside from adding a pleasing architectural design, major technical advantages accrue such as a decrease in the ship's draft, better stability and increased cruising speed. Hatch covers have been successfully fabricated for barges, resulting in a substantial reduction in weight and maintenance cost as well as ease in handling.

The dairy industry is employing aluminum containers and apparatus, among them a new bottle carrier, a portable cooler which is immersed in the milk can (Fig. 3), and cheese molds made of deep drawn aluminum alloy sheet (replacing the unhygienic wooden forms).

In agriculture the construction of feed silos is noteworthy. They have proven, after some years of service, that they are apparently indestructible; they can also be assembled or moved to a new location by unskilled workmen. Two types are available; one, which is more substantial, uses prefabricated 3 S segments bolted together, and another is a light-wall variety fashioned after a Swedish prototype which uses 3 S strip like siding, nailed to a wooden framework.

As could be expected from the geography of our country, aluminum has found many functional applications in the field of winter sports. Among others, a ski pole made of Al-Zn-Mg-Cu alloy has been developed, heat treated to 85,000 psi. tensile strength, 12% elongation and 175 Brinell hardness. This pole has proven its worth in international ski contests and expeditions to the Himalayan Mountains and the Andes. Avalanche-deflection roofs, snow sheds and snow fences have found increasing usefulness – especially since their efficiency is high, and the storage space in summer is small. They are made of galvanized steel wire fencing of 6-in. mesh interwoven with 4-in. strip, 0.3 mm. thick of 57 S alloy whose ends are turned back and riveted.

Many Alpine aerial tramways use light-metal cabs. The most advanced design calls for capacities of 40 passengers.

**Scientific progress** in Austria likewise leaves little to be desired, most of the work being primarily applied research.

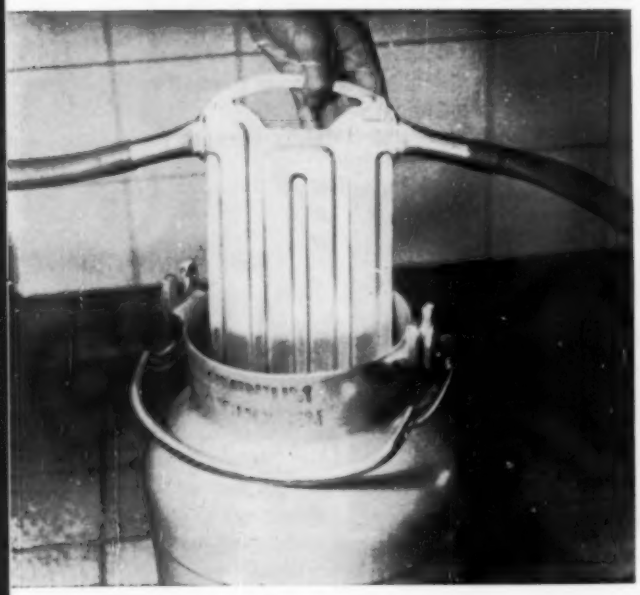
The extensive use of light metals for electrical applications and the necessity for exporting products strictly adhering to foreign specifications started some comprehensive studies of the interdependence of chemical composition, microstructure, degree of cold working, and strength.

First the variation in conductivity of high-purity aluminum (99.996% Al) as a function of traces of alloying elements was determined. The important impurities are primarily iron and silicon (the other tramp elements exerting only a subordinate influence). Both iron and silicon are largely dissolved in aluminum at 500° C. and have substantially precipitated at 350° C. These two structural states, the "homogeneous" or solution annealed condition, and the "heterogeneous" or artificially aged condition, must be considered in the examples cited.

The decrease in electrical conductivity of aluminum wire as a function of increasing deformation and strength is shown in Fig. 4, where the vertical ordinate is expressed in mho, $mm^2$., m. units. The microstructural characteristics exert a great deal of influence, since the curve for an aged wire is much higher than that for a solution heat treated grade. The difference can be as high as 0.5 unit of conductivity.

*Fig. 2 – Model of Glass Support for Greenhouse Construction – a V-Shaped Profile for Bearing and a Flat Hold-Down Strip of 57 S*

*Fig. 3 – Portable Cooler for Milk Cans. Two pieces of formed aluminum sheet, seam welded, carry a refrigerant liquid*



Superimposed on this phenomenon is the influence of the various impurities. Figure 5 shows the conductivity as a function of the silicon content for aluminum wire containing 0.1, 0.2, 0.3 and 0.4% iron, respectively. The graph on the left hand shows conductivity of wire that has been 95% cold deformed (hard drawn). The center is representative of wire with a precipitation hardened structure after aging at 350° C. Here the conductivity is much higher and the influence of Fe and Si less significant. The right-hand graph shows solution heat treated wire after 2 hr. at 500° C. and water quenching. As would be expected, the influence of elements in solid solution in the aluminum crystals is then much greater. It can also be observed that, generally speaking, the influence of silicon is greater than that of iron.

With decreasing amounts of impurities the difference in conductivity between "heterogeneously" and "homogeneously" annealed wire diminishes. Also noteworthy is the extremely small decrease in conductivity shown in Fig. 4 with increasing amounts of deformation or work hardening. This may be explained by the small number of lattice imperfections in high-purity alu-

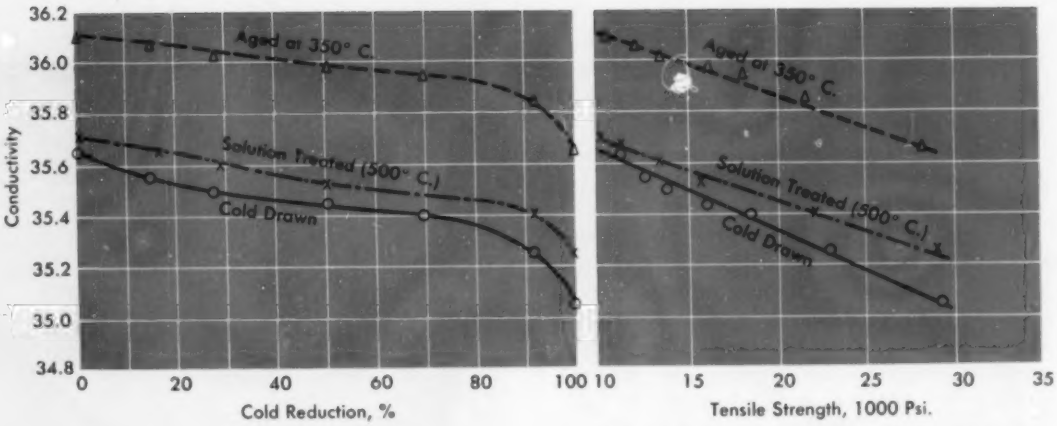



*Fig. 4 – Relation of Cold Reduction, Heat Treatment and Tensile Strength on Conductivity of High-Purity Aluminum Wire*

minum and slip along preferred directions. This phenomenon is of special significance in electrical engineering, since high-purity aluminum wire retains its high conductivity in the hard drawn condition.

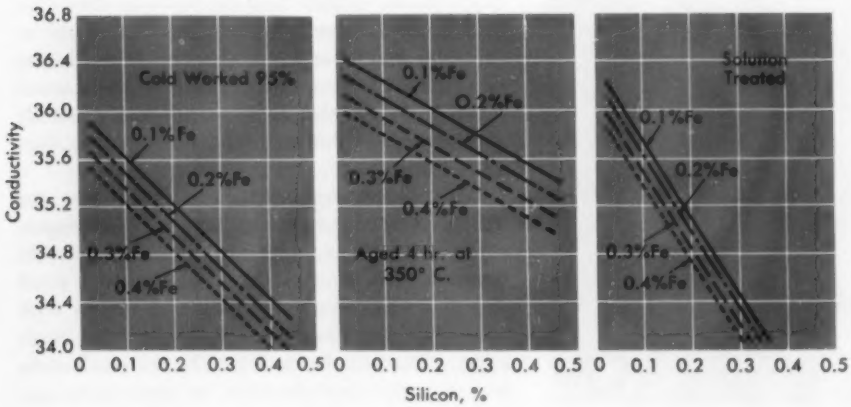
Somewhat more complicated are the circumstances surrounding the high-conductivity alloy Al-Mg-Si. Here the electrical conductivity is strongly influenced by the temperature-dependent solubility of the intermetallic compound $Mg_2Si$. Since composition limits for this alloy (0.5% Mg, 0.5% Si, nominal) are narrow due to to universally strict specifications in all countries, composition has little significance as to conductivity. On the other hand, because high tensile strength is normally required, a careful choice of production procedures is important to assure the best compromise of optimum conductivity and acceptable strength.

These exhaustive investigations on conductor materials now give us a better understanding of manufacturing processes designed to combine the best possible mechanical and electrical values, and this information will eventually lead to the establishment of useful standards.

**Aluminum Nails** – Another problem was posed by the manufacture of light-metal nails. Although an aluminum nail is decidedly superior to a galvanized steel nail, because of its proven resistance to both weathering and the combined corrosive influences of industrial atmospheres and wet wood, there has been much sales resistance. The only valid reason for this was that the nails either split the wood if they were too large in diameter, or buckled on being driven into hardwood because of inadequate stiffness of the aluminum alloy used. In the absence of applicable specifications and reliable test data, it was necessary to develop a slenderness ratio of the nail to its resistance to buckling.

Using known values of buckling strength for

*Fig. 5 – Relation of Iron and Silicon Content, and the Effect of Cold Work and Heat Treatment on the Electrical Conductivity of Aluminum Wire*



iron nails and experimenting with various aluminum alloys, the necessary dimensions for light-metal nails having adequate properties were determined. Practice proved theories to be correct and aluminum nails that were the equivalent of iron nails have been put on the market.

As to choice of alloy, it should be mentioned that the high-strength Al-Cu-Mg grade is preferred to the copper-free Al-Mg-Si and Al-Mg alloys for its superior resistance to corrosion. The hardenable alloy can be hard drawn and headed prior to heat treatment. However, heat treating results in an unsightly surface appearance unless the nails are pickled. Alloy Al-Mg-Si is preferred where the hardest wires are processed by automatic machines.

**Sheet for Deep Drawing** – In another fundamental study the factors influencing "earing" of deep drawing sheet were determined. After considering the influence of a homogenizing anneal, hot rolling as well as cold rolling, and modifying the melting practice, it was possible, with the aid of advanced X-ray techniques, to manufacture a deep drawing quality sheet which is practically free from any earing tendency.

**Beryllium Additions** – Extensive investigations evaluated the effect of small additions of beryllium to heats of aluminum and Al-Mg alloys. As little as 0.002% Be diminishes the magnesium melting loss substantially, whereas 0.005% Be prevents the damaging influence of moisture in green sand molds. About 0.3% Be is effective in promoting an especially adherent and uniformly thin dip coat of aluminum on iron.

The examples of technical and scientific developments cited here prove that Austria is today capable of contributing its share to the broader use of aluminum throughout the world.

# International Progress in the Light Metal Industry

*By FRANCIS C. FRARY**

**Reports presented at the Third International Light Metal Congress indicate the tremendous expansion in world-wide production and use of the light metals. (A 4, Al, Mg)**

THE THIRD INTERNATIONAL Light Metal Congress was held in June 1956 at the Austrian School of Mines and Metallurgy in Leoben, a town about 125 miles southwest of Vienna. R. Mitsche, professor of metallurgy, was in general charge of the Congress, which had a registration of about 300 and was sponsored by the Austrian companies Vereinigte Aluminiumwerke A.G. and the Oesterreichische Metallwerke A.G. of Ranshofen, the Metallwerke Plansee of Reutte, Tirol and the Salzburger Aluminium G.m.b.H. of Lend.

After the customary official greetings, the Congress heard seven reports which gave an authoritative survey of the role of the light metals

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in the economies of the British Commonwealth, West Germany, France, the United States, Austria, Switzerland and Great Britain.

**Production in Various Countries**

In Canada, the major producer in the British Commonwealth (609,600 tons in 1955), a very large amount (3,200,000 hp.) of hydro-electric power is installed and operated by the aluminum industry, substantially all for the production of aluminum. This is expected to increase to 4,580,000 hp. in 1960. The present 150,000-ton annual production at Kitimat, B. C., is soon to be doubled, and the Aluminum Co. of Canada has announced a 300,000-ton per year increase in their already-large Quebec production. A new 80,000-ton plant is also being built there by a subsidiary of the British Aluminium Co. About 75% of the aluminum produced in Canada is exported, bringing in $212 million in 1955. Aluminum is fifth in order of importance among Canadian exports. Magnesium production in the United Kingdom is limited by the shortage of power to 1500 tons per year; that of Canada is 9000 tons.

Germany, which before the war was the largest producer in the world of both aluminum and magnesium, lost all this production in 1945 and has since gradually brought its aluminum production up to 137,100 metric tons in 1955 (150,000 short tons of 2000 lb., or 4.4% of the world production), and its magnesium production to a few hundred tons. Consumption has so greatly exceeded production that the tariff on aluminum imports, imposed to offset the high cost of power in Germany, has been temporarily suspended.

In France, the 1955 production of 129,175 metric tons (142,000 tons) was more than twice that of 1950 and nearly three times that of 1938. Further expansion in France is prevented by the high cost of new power, so the industry has turned to Africa. A French plant in the Cameroon Province of West Africa is almost completed and a large development in French Guinea or Central Congo is being planned jointly by the German, French, Italian and Swiss producers. French aluminum consumption amounted to 108,500 metric tons (120,000 tons), in 1955, 3½ times the 1938 figure. Development of larger cells and improved practices has reduced the labor to produce a metric ton of aluminum from 120 man-hr. in 1939 to 32.5 in 1955 (29.6 man-hr. per ton). In the period between October 1951 and January 1956, because of changes in taxation, the French price (less taxes) has been reduced from 181 to 174.26 francs (22.5¢ per lb.), while the U.S. price rose to 24¢ per lb. (Hourly wages in the U. S. are several times those in France.) The chief use of aluminum in France is in the transportation industry including aviation (34.3% of the total); the electrical industry took 19.5%, machine construction 11.2% and packaging 9.5% of the total. The construction industry used only 4.5% of the total but its share is increasing.

Production in Austria is by hydro-electric power, supplemented by steam power in winter. Production in 1955 was 57,500 metric tons, or 63,250 short tons, from imported raw materials. Domestic demand has increased so much that soon the amount exported will be limited to that required to purchase the raw materials. The Austrian price for the pig metal is reported to be the lowest in the world but finished products are not proportionally cheap. There is considerable undeveloped water power in the Austrian Alps but in most instances, the water flow is greatly reduced in winter.*

The United States, with the largest production of primary aluminum in the world (more than 1,500,000 tons in 1955), had to import nearly 200,000 tons from Canada to supply its needs last year. The construction and transportation industries consumed the largest amounts (300,000 tons each), while the electrical industry used 200,000 tons; 100,000 tons went into foil. During the War, military uses took 90% of the production; now they require only about 10%. Large increases in producing and fabricating capacity are needed and are being planned or constructed. Magnesium production in the United States is the largest in the world, reaching a total of 61,135 tons in 1955.

The Swiss production of aluminum, while low in actual tonnage (33,000 tons), is large in terms of pound per capita (about 17.6 lb. per year) because the country is so small. Before the war, most of the metal was exported, domestic consumption being less than 20% of the production. Now consumption has about overtaken production. Subsidiary companies of the Swiss producer (A.I.A.G.) in other countries produce the needed alumina and fabricate some of the metal to foil. Besides the domestic production, about 10,000 tons per year of imported metal is converted to wrought products and re-exported. Aluminum foil may be considered to be a Swiss invention

*For further information on the Austrian situation see the article by Dr. Nachtigall on p. 77.

and 60 to 70% of the production is exported.

In Great Britain, domestic production is limited by the small amount of hydro-electric power available. Domestic production of 27,400 short tons was supplemented by 107,000 tons of secondary metal recovered and 290,000 tons of imported metal. Practically all of this was for domestic consumption with exports of only 4100 tons. Fabricating facilities are second only to those in the United States in capacity, and domestic consumption was 13.13 lb. per capita. Surface transportation consumed 26.5% of this, domestic and office equipment 11%, packaging 9%, and the construction and electrical industries 8.5% each. Uses in all fields are increasing rapidly.

**Superpurity Aluminum**

Superpurity aluminum (99.99%) is being made in several countries by the electrolytic refining process in cells using 20,000 to 40,000 amp. Because of its softness and workability, the metal is used in England for flashings to replace the customary lead-sheet flashings. It is also used in Europe (alloyed with a little magnesium) for reflectors, automobile trim and costume jewelry.

**Technology and Uses**

Other papers constituted two symposiums. One, on the technology of the light metals, included papers on the development of light metal foundry practice (especially gating); methods of recovering secondary metal; forging, rolling and extrusion techniques (including the study of internal stresses in forgings); recently developed welding processes for aluminum (arc, inert-arc flash and seam welding) and surface treatment.

Anodized and colored aluminum is receiving a great deal of interest all over Europe, and all the aluminum producers are actively working on surface treatments. The gold color (where the pigment is an iron oxide) is particularly popular for architectural uses.

A paper on English experience in continuous casting and rolling of aluminum slab as raw material for impact extrusion slugs completed this symposium.

Another session covered problems in the metallurgy, metallography and physics of the light metals. A discussion of the effect of superheating molten aluminum and magnesium on the as-cast structure was followed by papers on powder metallurgy, fatigue behavior, extrusion problems (particularly grain size and structure) and the use of light metals in atomic energy installations. Two items, not on the printed program, included a good discussion of the conditions governing the formation of "ears" in drawing aluminum sheet, and a profusely illustrated discussion of the development of all types of new aluminum products in the United States.

The symposium on the applications of light metal products was introduced by a discussion of such uses in Austria where 3% of the metal was used last year in the electrical industry because of railroad electrification. The other uses mentioned were conventional except for hatch covers on barges, silos for green fodder and snow fences (thin sheet hung on a wire framework). Papers on the use of aluminum in the transportation industry, in cans (to replace tinplate for certain foods) and in the electrical industry concluded the symposium.

As in the United States, aluminum is in short supply in Europe and importation of part of the metal required is generally necessary. The increased demand is reflected in enlarged research laboratory facilities and staff of the producers in most of the countries. A large part of the work done is in the nature of sales development to improve the competitive position of the metal. English efforts in this respect are particularly effective and include a new corrugated aluminum sheath for electric and telephone cables developed by the British General Electric Co. Formed out of strip sheet, welded and corrugated upon the cable, it permits bending over a much smaller radius than would be feasible with the usual close-fitting sheath.

The shortage of aluminum appears to extend behind the Iron Curtain; new aluminum plants are planned in both Hungary and Czechoslovakia to increase their present annual capacities of about 50,000 metric tons. The presence at the Congress of 46 people from behind the Iron Curtain testified to the active Eastern interest in the light metals and their uses.

Of the 33 papers, four were presented in English, four in French and the remainder in German. All registrants were furnished a 120-page pamphlet containing rather extensive abstracts of all the papers (except the Russian ones) in all three languages. The Russian papers were unexpected and consequently could not be included in the preprinted abstracts. All the papers will be published later in the summer in a single volume by the school. The price will be about $6.00 and Prof. R. Mitsche, Montanistische Hochschule, Leoben, Austria, will handle the sales of the book.

# Improved Foundry Compositions

*By A. WITTMOSER**

**Traces of tramp elements have been found to be responsible for many costly aberrations in foundry products. At the same time, small additions of unusual elements will control microstructure in pearlitic gray iron, reduce annealing time for malleable castings, and improve tensile properties of alloy cast steels. (E 25, CI)**

As FOR MOST other engineering alloys, numerous characteristic mechanical properties have been included in specifications for iron-carbon alloys, and are used by the purchaser when he orders steel, malleable, or gray iron castings. These desired properties, established for this widely used group of materials of construction as the result of many decades of practical experience, are dependent primarily upon the presence of carbon, silicon, manganese, phosphorus and sulphur in the alloy. Moreover, the characteristics of cast products may be influenced to an unusually important degree by special treatments such as annealing, enameling, quench hardening and others, depending upon the use to which the part is put and upon the microstructural condition, primarily of carbon but also of the other elements named.

As soon as the German foundry industry began to sell its product to consumers who insisted on high and uniform quality, it was recognized that the influence on cast ferrous products of these common addition elements, either singly or in any of the innumerable possible combinations, often seemed quite erratic. This led to many carefully planned series of investigations and the accumulation of a vast amount of apparently authentic data. The desired result was not always attained. Though optimum operating conditions were strictly adhered to, unexplained anomalies continued — often of a very serious nature. Impact strength and elongation, for instance, had a tendency to exhibit periodic or abnormal low average values to such an extent that the daily and weekly scrap production rose alarmingly. These inconsistencies were observed in all members of the ferrous family. Steel castings would exhibit a decided epidemic of hot tearing, while malleable castings fell victim to unexplainable graphitization phenomena or troublesome resistance to ready malleablization and concomitant pinhole porosity. Cast iron parts would show abnormal shrinkage or unorthodox graphite flake formation. All these occurrences definitely proved that certain factors were operating which had not been adequately investigated or had stubbornly defied identification.

Some years ago the steel casting industry had been enriched by extensive data relative to the cause and elimination of brittleness and shrinkage porosity. It was suggested in some of this

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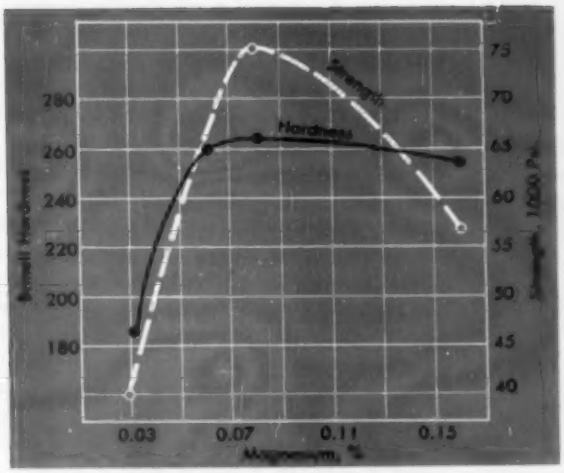



*Fig. 1 – Influence of a Small Magnesium Addition on Hardness and Strength of a Gray Iron, According to O. Carlson*

work that an investigation of the influence of small amounts of oxygen, nitrogen and hydrogen in ferrous castings might prove fruitful. As a result of some excellent work along these lines the frequency of occurrence of the above-mentioned difficulties was somewhat reduced, and some metallurgists felt that the influence of gases was the key to the mystery. However, subsequent experience showed that only a small part of the steadily recurring operational difficulties could be traced to the direct effect of oxygen, nitrogen and hydrogen. Obviously other detrimental influences were at work which could have their origin in the raw materials and which would be retained, substantially unmitigated even through repeated remeltings. Thus it happened that one heard the word "heredity" in discussions of these undesirable phenomena.

### Trace Elements Other Than Gases

Painstaking evaluation of both systematic research data and widely scattered individual reports led to the surprising conclusion that several elements, which had thus far remained virtually unnoticed because they occurred in such small quantities, could exert an astonishingly powerful influence on important properties of alloys in the iron-carbon group. Even when present in infinitesimal amounts, certain elements markedly enhanced technically important properties whereas others had a decidedly harmful influence. Still other elements exerted an optimum beneficial effect when present in certain threshold amounts; if these values were exceeded the effect was reversed – again quite strongly.

It is also characteristic of this group of elements that they retain their striking effectiveness on members of the cast iron-carbon alloy family down to quantities as low as 0.1% and, in certain instances, even to 0.001%. Similar phenomena have been reported for alloys of other metals besides iron, the most familiar being the influence of sodium on the crystallization of the Al-Si alloys. A parallel is also found in living organisms, where the presence of very small amounts of certain elements may cause profound changes. Typical examples are the boron content of the soil in wine-growing districts and the calcium level in the blood of mammals.

While there have been scattered reports of the effect of trace elements on iron alloys, only in the past 20 years has there been a concerted effort to clarify their influence on gray iron, where graphite formation far outweighs all other factors governing the mechanical properties. A systematic study of the influence of trace elements on the formation and shape of graphite led to the scientifically and technically significant realization that very small amounts of certain elements may change the graphite type from a coarse lamellar to a fine, almost ideally spherical shape. This discovery of iron, "malleable as cast", was naturally followed by a wealth of experimentation, both in Europe and in America. These investigations on cast iron in turn stimulated work of a similar nature on steel castings and have lately influenced the manufacture of certain high-alloy steels.

Since it would be impossible to describe exhaustively the many influences exerted on the properties of iron-carbon alloys by trace elements, it will suffice to list a few characteristic instances of special technical significance.

The type of graphite occurring in alloys of cast iron is modified by certain elements such as cerium and alkaline earths when present in hundredths of one per cent. If certain conditions are met, 0.04 to 0.08% Mg may result in a marked improvement of all mechanical properties of cast iron and the occurrence of what might be called a certain degree of plasticity. This is shown in Fig. 1. These curves show a definite peak past which the beneficial effect of magnesium decreases with increasing amounts of the alloying addition.

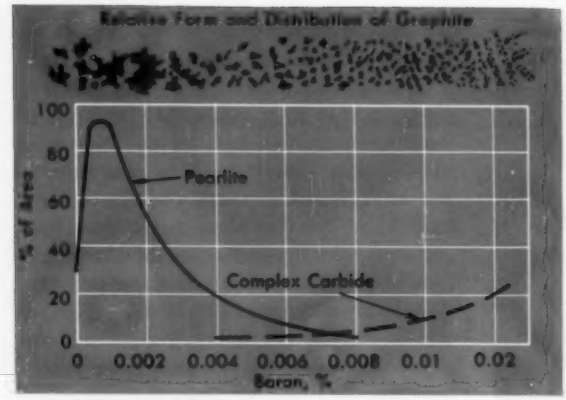



*Fig. 2 – Influence of Boron on the Form of the Carbide in Malleable Iron as Cast and of the Size and Distribution of Graphite After Annealing. (R. W. Heine, "Deoxidation of White Cast Iron", Foundry, August 1949, p. 74)*

A check on other elements having a similar influence led to the discovery of a number of metals and alloys which showed a definite tendency to favor the formation of spheroidal graphite gray irons. It was also found that some trace elements, such as lead, arsenic and aluminum, would "poison" the influence of other trace materials in liquid iron which promote the formation of spheroidal graphite. In "uninoculated irons" these same trace elements would influence unfavorably the normal graphitization process.

These findings, in turn, served to explain the fact that, according to persistent observation, the presence of certain raw materials in the charge favored the formation of spheroidal graphite, whereas other components – in spite of quite liberal additions of inoculating elements – failed completely to produce this type of graphite.

The matrix structure of various gray irons, also, can be detrimentally influenced by certain small amounts of trace elements. Minute percentages of tin suppress the formation of ferrite, in fact 0.02% tin is as potent as 5 to 6% nickel or 3 to 4% copper would be under comparable circumstances.

### Graphitization of White Iron

While improvement in strength, together with an improvement in toughness, was foremost in the minds of those who developed high-quality gray irons, the malleable foundryman was most interested in solving the knotty problem of deviations from regular heat treating cycles, necessary for the graphitization of the carbides in white iron.

An investigation on the influence of trace elements on the stability of iron carbide in white iron for malleable foundries led, in a relatively short period of time, to the isolation of a num-

**Table I – Trace Elements in Cast Iron-Carbon Alloys**

| Element | Minimum Effective Amount | Cast Steel | Malleable Iron | Cast Iron With | |
|---|---|---|---|---|---|
| | | | | Spheroidal Graphite | Lamellar Graphite |
| Aluminum | 0.001% | + | + | – | + |
| Antimony | 0.004 | 0 | + | – | + |
| Arsenic | 0.001 | – | – | – | – |
| Barium | 0.001 | 0 | + | – | + |
| Bismuth | 0.0005 | 0 | + (–) | – | + (–) |
| Boron | 0.0001 | + | + | + | – |
| Calcium | 0.001 | + | + | + | + |
| Cerium and rare earths | 0.005 | + | + | + | + |
| Lead | 0.0001 | + | – | – | – |
| Lithium | 0.005 | + | + | + | + |
| Magnesium | 0.005 | + | + | + | + |
| Selenium | 0.001 | + | + | + | + |
| Sodium | 0.0001 | 0 | + | + | + |
| Strontium | 0.001 | 0 | + | + | + |
| Tellurium | 0.0001 | 0 | + | + | + |
| Tin | 0.01 | – | 0 | – | + |
| Titanium | 0.01 | + | – | – | + |
| Zinc | 0.001 | – | – | + | – |
| Zirconium | 0.001 | 0 | + | + | + |

Legend: + Favorable – Unfavorable 0 Not determined

ber of elements whose presence in amounts as low as 0.001% was sufficient to cut the necessary annealing cycles to a fraction of their former length.

Among these trace elements are tellurium, titanium, boron, bismuth and aluminum. Malleable iron is especially sensitive to the influence of trace elements, because most of the metals favoring carbide decomposition of white iron are already acting as graphitizers during freezing of the melt and thereby endanger the absolutely necessary completely white fracture in the as-cast state. For this reason only those elements are especially effective which favorably effect the formation of completely white iron but decrease the annealing time. Boron and magnesium are examples. Figure 2 shows that boron has an optimum effect on decomposition of carbides in amounts between 0.06 and 0.08%. Adding an excess increases the stability of iron carbides to such an extent that the annealing cycles have to be lengthened far beyond those necessary for iron completely free of boron.

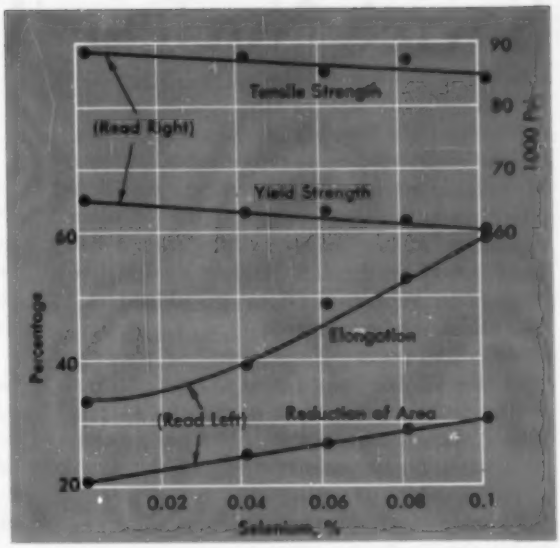



*Fig. 3 — Influence of a Small Amount of Selenium on the Tensile Properties of a Cast Steel Analyzing 0.30 C, 0.35 Si, 1.5 Ni, 1.5 Mn, 0.06 Al. (A. P. Gagnebin, "Selenium Additions in Cast Steel", American Foundryman, August 1947, p. 43)*

Another instance has been presented by Mr. Boegehold in *Metal Progress* for last October, where he shows that 0.025% bismuth plus 0.003% boron will not only produce an iron which can be malleableized in a short cycle but which also produces completely white fractures in unusually large castings.

### Trace Elements in Cast Steel

The judicious addition of trace elements to cast steel has also been found to be beneficial. Under certain conditions grain-boundary films and segregates are formed to the detriment of impact strength and elongation values. Additions of rare earth metals, especially cerium "misch metal", eliminate much of these undesirable conditions. Selenium is also effective, and Fig. 3 shows the effect of treating a ladle of cast steel with small quantities of it. Reduction of area and elongation are improved to a remarkable extent by this inoculation.

Similar spectacular results have been noted after stainless steels had been treated with selenium and rare earth metals. By introducing such elements in minute quantities impurities that were originally distributed as films along grain boundaries are coagulated into relatively harmless particles. The very poor hot working characteristics of the high-alloy steels can often be appreciably improved. It was interesting to observe that an addition of misch metal (a master alloy consisting of a number of the rare earth metals) proved more efficient than an equal amount of each of the several individual elements in its make-up.

### Summary

How diversified the effects of various trace elements may be on the several alloys of the iron-carbon group is summarized in Table I, which is self-explanatory. (The information was assembled from existing literature references and no claim is made to completeness.)

Unquestionably our knowledge of potency of various trace elements on iron-carbon alloys is but in its infancy. However, the intelligent and systematic evaluation of widely scattered data has already solved problems of real practical significance and shown the way toward industrial progress.

By analogy, we may expect that some of the findings concerning the value of trace elements in iron-carbon casting alloys may be helpful in other branches of metallurgical science and should spark additional research in related fields of science and technology.

# Soviet Nuclear Tests

THE FOLLOWING is a chronological summary of official statements concerning the Soviet effort toward manufacture and use of atomic explosives. At the end are extracts from a statement issued by the U.S. Atomic Energy Commission on Sept. 3, 1956 as an addendum to this list of pronouncements.

MOLOTOV: *The "secret" of the atom bomb has "long ceased to exist". 11/6/47.*

VISHINSKY: *It is a mistake to think there is just one state which has a monopoly over atomic energy and the atomic bomb. 10/1/48.*

TRUMAN: We have evidence that within recent weeks an atomic explosion occurred in the U.S.S.R. 9/23/49.

TASS: *"Despite the existence in its country of an atomic weapon," the Soviet government would continue to demand "absolute prohibition of the use of atomic weapons". 9/24/49.*

TRUMAN: "Another atomic bomb has recently been exploded within the Soviet Union. In spite of Soviet pretentions that their atomic energy program is being directed exclusively toward peaceful purposes, this event confirms again that the Soviet Union is continuing to make atomic weapons." 10/3/51.

STALIN: *"Indeed, one of the types of atomic bombs was recently tested in our country. Tests of atomic bombs of different calibers will be conducted in the future as well, in accord with the plan for defense of our country from attack by the Anglo-American aggressive bloc." 10/6/51.*

TRUMAN: "Another atomic explosion has occurred within the Soviet Union apparently as a part of a test series. Of course, there may be more explosions from time to time." 10/22/51.

MALENKOV: *"The U.S.A. has long since lost the monopoly in the matter of the production of atomic bombs. . . . The government deems it necessary to report to the Supreme Soviet that the U.S. has no monopoly in the production of the hydrogen bomb either." 8/8/53.*

STRAUSS: (in reply to Malenkov): We have never assumed that it was beyond the capability of the Russians to produce such a weapon and that is the reason why, more than three years ago, it was decided to press forward with this development for ourselves." 8/8/53.

STRAUSS: "The Soviet Union conducted an atomic test on the morning of Aug. 12. Certain information to this effect came into our hands that night. Subsequent information on the subject indicates that this test involved both fission and thermonuclear reactions." 8/20/53.

PRAVDA AND IZVESTIA: *"One of a variety of hydrogen bombs was exploded for experimental purposes in the Soviet Union within the past few days. Because a powerful thermonuclear reaction was created in the hydrogen bomb, the explosion was of great strength. The tests showed that the power of the hydrogen bomb is many times greater than the power of the atom bomb. It is known that the Soviet Union has had the atomic weapon for several years and has conducted suitable tests." 8/20/53.*

U.S. ATOMIC ENERGY COMMISSION: "On Aug. 23, 1953, a fission explosion took place in Russian territory. The explosion was in the same range of energy release as our Nevada tests and would appear to be part of a series. If this proves to be the fact, no further announcements will be made." 8/31/53.

TASS *announcement, concerning test of new types of atomic bombs in the Soviet Union, said that "in recent weeks, in accordance with the plan of scientific research work in the field of atomic energy in the Soviet Union, tests have been held of several types of atomic bombs. Tests were successful." 9/18/53.*

STRAUSS: "There has been a series of detonations of nuclear explosives in Soviet territory. This series began in mid-September and has continued at intervals to the present. As is generally the case with nuclear detonations, these tests have

resulted in some widespread fall-out of radioactive material, but insignificantly in the United States." 10/26/54.

A.E.C.: "Within the past few days the Soviets have resumed testing of nuclear weapons. This may mean the beginning of a new test series." 8/4/55.

STRAUSS: "Another Soviet nuclear explosion has occurred in recent days, indicating a continuation of their tests of nuclear weapons." 9/24/55.

STRAUSS: "The Soviet Union has, in recent days, conducted a further nuclear test in their 1955 series." 11/10/55.

STRAUSS: "Another explosion has taken place in the current Soviet test series. It was the largest thus far in the U.S.S.R. and was in the range of megatons. The Russian tests indicate an increasingly intensive effort by the Soviet government to develop their nuclear weapons potential." 11/23/55.

KHRUSHCHEV *announced that the Soviets had just set off a nuclear weapon of "unprecedented might", and involving a new method of explosion. He gave the assurance that although this new weapon was intended to "influence the nerves of those who would like to unleash a new war", the Soviets would never be the first to use "this new power". 11/26/55.*

KHRUSHCHEV *before Supreme Soviet recalled the results of the recent Soviet tests of the latest hydrogen bomb. He declared that its power is equal to the power of many million tons of the usual explosives and "that it can be substantially increased". 12/29/55.*

MARSHALL GHUYKOV: *"U.S.A. monopoly of atomic weapons has long since been liquidated, and the Soviet Union has surpassed the United States in hydrogen weapons". 1/21/56.*

STRAUSS: "Within the past few days the Soviets have exploded another nuclear device. This is the fifth United States announcement of Soviet nuclear weapon tests in the past eight months. 3/21/56.

STRAUSS: "The Soviet Union in recent days has conducted another nuclear test in their current series." 4/2/56.

KABANOV: *"Of course, we do not conceal the fact that in the event we are compelled to use atomic energy for military purposes, we shall not hesitate to use it for military purposes." 4/12/56.*

KHRUSHCHEV: *"It remains a fact that we were the first to explode an H-bomb from an airplane. . . . Great stress is being laid now on guided missiles. . . . I am quite sure that we will have the guided missile with an H-bomb warhead which can land anywhere in the world." 4/23/56.*

**Extracts From A.E.C. Statement, 9/3/56:**

The Soviet Union has resumed its testing of nuclear weapons, and on Aug. 24, 1956 detonated a nuclear device with a yield of less than a megaton at their proving ground in Southwest Siberia, north of Afghanistan. The Soviets have also utilized the Barents Sea for nuclear testing.

This is the 13th announcement by the United States concerning nuclear weapons tests made by the U.S.S.R.

The Soviet Union has never given the world any assurances with respect to the way in which it conducts nuclear weapons tests and has never made any advance announcement of its tests.

The record of U.S. announcements gives clear evidence that the Soviet's nuclear weapons testing activity has been on a steadily increasing scale, as follows:

1949: Sept. 23
1951: Oct. 3
Oct. 22
1953: Aug. 20
Aug. 31 (one of a series of explosions)
1954: Oct. 26 (one of a series of explosions)
1955: Aug. 4
Sept. 24 (one of a series of explosions)
Nov. 23
1956: March 21
April 2 (one of a series of explosions)
Sept. 3

Although there have been 13 announcements by the U.S. regarding Soviet testing, the actual number of detonations is significantly higher.

The secrecy of the Soviet test program contrasts with the responsible public information policy of our Government with respect to the U.S. test program. All such test programs have been announced well in advance. Two recent detonations at Eniwetok were witnessed by representatives of the U.S. press, radio and television so that they could report to the world regarding the way in which U.S. tests are carried on. Representatives of U.S. foreign news media also have witnessed "open shots" of weapons tests at the Nevada Proving Ground.

# Quality Control of High-Temperature Alloys

*By G. T. HARRIS**

**If the variation in properties of high-temperature alloys were reduced, the alloys could be used at higher temperatures or higher stress levels than are now safe. Vacuum melting appears to be one method of reducing the variation. (S 12, SG-h)**

A GREAT DEAL of attention has been given in the last few years to the determination of the creep and fatigue properties of heat resisting steels, but far too little emphasis has been placed on determining the scatter of results to be expected. This scatter is important for two reasons. The first concerns the engineer who needs to know the worst about his materials. The metallurgist who has developed a new alloy or heat treatment tends either to quote the maximum properties obtained or, if he is more honest, the average properties obtainable. The minimum properties are actually the important ones so that a suitable factor of safety is applied to the quoted figures. The fact that there is such a large scatter in the results obtained on nominally similar material shows that there is insufficient knowledge of the basic metallurgical factors underlying these properties, and a proper correlation of the scatter with metallurgical background can yield dividends almost as profitable as the exploration of alloy systems themselves.

As an example of the importance of this, an increase in the working stress or temperature in an austenitic alloy can often be achieved simply by increasing the percentage of one or more of the alloying elements. Thus, for a particular austenitic alloy, the creep properties can be raised 15% at 1400° F. by increasing the cobalt content by 10%, but this would increase the price of the finished alloy in bar form from $3.00 to $3.80 per lb. This type of alloy may have a scatter band of ± 30%, and if by stricter metallurgical control this could be halved to ± 15%, the engineer could have the same result without an increase in price.

The investigation of scatter reported in this paper is by no means complete but it is put forward to stimulate thought and discussion. It arose primarily from a consideration of the materials available to withstand typical gas turbine blade operating conditions at temperatures of the order of 1700 to 1800° F. In the course of examining suitable materials, it became clear that two classes of material merited consideration apart from the standard heat treated wrought alloys. In Britain, turbine blades for jet engines have almost from the inception been made from one of the nickel-base titanium-aluminum alloys of the Nimonic series. These have served well but as with all alloys there is always a steady decrease in properties above a certain temperature range. The maximum permissible operating temperature has been raised progressively as a result of intensive alloy development, but an examination of Fig. 1 will show that even for the latest developments, the limiting temperature cannot exceed about 1700° F. The alloys shown in Fig. 1 also include a cobalt-rich forging alloy (G 32), a cobalt-rich casting alloy (G 34) and an iron-base warm worked material (G 42 B). Although the properties of these alloys are not outstanding at the lower temperatures, the decrease with temperature is less and at 1700 to 1800° F., they are in general stronger than the hardened nickel-base materials hardened with titanium and aluminum.

The compositions of these materials are shown

*Research Director, William Jessop & Sons Ltd., Sheffield, England. H. C. Child and J. F. Howard of the same firm assisted in the collection and analysis of the data presented in this article.

**Table I – Composition and Cost of Alloys in High-Temperature Materials**

| Element | Nimonic 90 | Nimonic 95 | G 32 and G 34 | G 42 B |
|---|---|---|---|---|
| Nickel | 56% | 56% | 12% | 15% |
| Chromium | 20 | 20 | 19 | 19 |
| Cobalt | 18 | 18 | 45 | 24 |
| Iron | — | — | 18 | 35 |
| Tungsten | — | — | — | 3.0 |
| Molybdenum | — | — | 2.0 | 3.0 |
| Columbium | — | — | 1.2 | — |
| Titanium | 2.5 | 2.8 | — | 0.8 |
| Aluminum | 1.5 | 1.8 | — | — |
| Vanadium | — | — | 2.8 | — |
| Cost* | $1.032 | $1.048 | $1.524 | $0.961 |

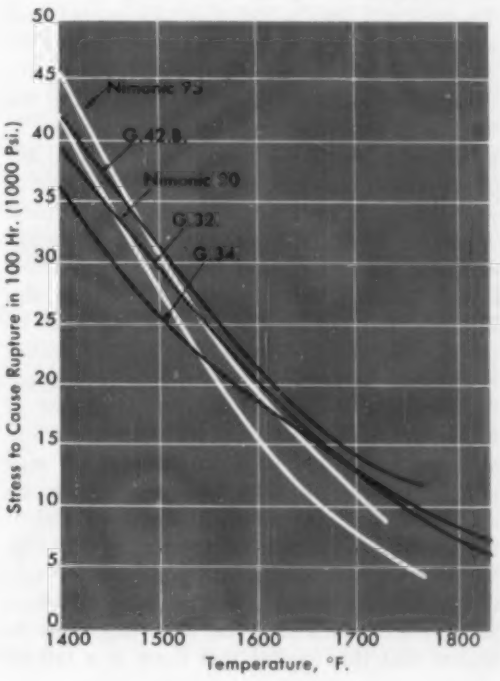
*Per pound of alloying elements.

in Table I. The forging alloy (G 32) was developed as the result of systematic investigation of the addition of carbide-formers to a nickel-chromium-cobalt austenitic base. The first base employed 20% each of nickel, chromium and cobalt, and the effect of additions of tungsten, molybdenum, columbium, titanium and aluminum against carbon was studied. The results indicated that suitable proportions of molybdenum, columbium, vanadium and carbon were likely to give the best rupture strength for this base. A similar study of the cobalt, iron, nickel and chromium content of the base using 3% W, 3% Mo, 3% Cb and 0.5% C additions showed that a 45% Co, 12% Ni, 20% Cr base would give the best balance of high rupture strength, low cost and machinability. The best alloy containing 2.8% V, 2.0% Mo and 1.2% Cb was designated G 32.

This alloy, although developed several years ago, shows a surprisingly good creep strength at temperatures of about 1800° F. The cobalt-rich casting alloy, G 34, was developed from G 32 by varying the carbon content of alloys of this type until an optimum composition was obtained which combined good creep strength, good castability and sufficient ductility for use as a precision casting alloy. The properties of this alloy are attractive but due to early unfortunate experiences in the use of cast alloys in British gas turbines, there was reluctance to its adoption for rotating blading. It should be remembered that no cast blade has been used in a British jet engine for a rotating part for 12 years. It was decided, therefore, to investigate more fully the scatter that was to be expected from the use of cast materials.

The second alternative to conventional wrought materials was that of using a warm worked material as represented by G 42 B. The fundamental principle underlying warm working is that the application of plastic deformation in the precipitating range of temperature is more efficient in raising creep strength than simple thermal aging alone. It is important to note that warm working is not the same as cold working which in general has the same effect of raising the proof stress at room temperature but sometimes decreases creep strength. In contrast to this, warm working will raise both the room-temperature and the elevated-temperature properties, and under suitable circumstances its effect will be maintained for long times even at temperatures greatly exceeding the temperature of warm working. It was at one time considered that warm working at 1300° F., for example, would be of no benefit to an alloy which was to operate at 1500° F., but it has been proved that the advantage can be maintained even up to 400° F. above the warm working temperature. The cost of manufactur-

*Fig. 1 – Stress-Rupture Properties of Several High-Temperature Alloys*



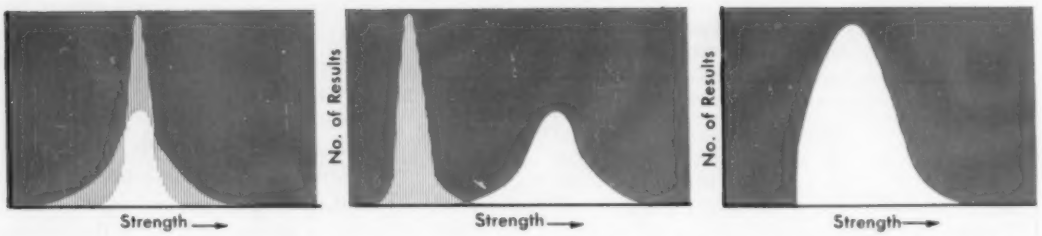


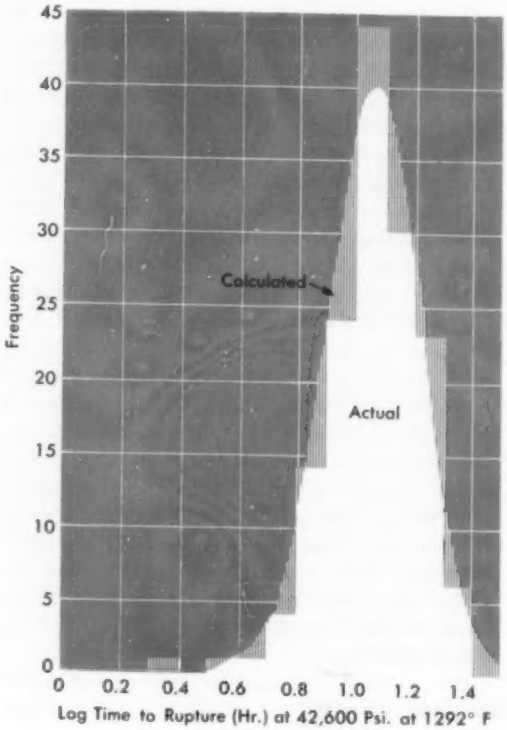

*Fig. 2 – Possible Frequency Distributions of Rupture Strength of a Heat Resisting Alloy*

ing an alloy is, of course, dependent upon a great many factors, particularly the yield of sound material and the remelting value of the scrap besides the simple cost of the alloying elements contained. Nevertheless, Table I, which shows the cost of the alloying elements in these alloys, demonstrates the economic advantages which can be obtained if comparable yields of sound bar can be achieved.

Again, however, there was some doubt whether the use of warm worked material for turbine blades would lead to greater scatter than was currently obtained on heat treatable wrought alloys. This applied particularly to the use of warm worked drop stamped turbine blades where each blade was individually warm worked. Development of the technique involved research into suitable die designs followed by an investigation of the scatter of creep properties.

Some features that may be expected in any investigation on scatter are shown in Fig. 2. The type of scatter which may be expected from two materials, one with a narrow scatter and the other a broad scatter band but both having the same mean value of properties, is shown at the left. It is clear that the engineer will prefer to have the one with the narrow scatter band because he can design more closely to the average properties. A material of broad scatter band which has, however, a very much higher average strength than the other material of narrow scatter band is shown in the center. In this instance, the engineer may well say that he prefers the material with the greater scatter because he is unlikely to obtain a component of a strength as low as the average of that of the narrow-band material. In certain circumstances, the normal Gaussian distribution may not be completely valid because there is an artificial cut-off particularly at the lower end of the scatter band as indicated at the right in Fig. 2. Plotting the mechanical properties of materials normally gives a scatter band which is substantially Gaussian, but it is important to realize that this implies that there is a tail on the low side of the diagram which suggests that an occasional specimen will be found with a value very much lower than the mean. It is important to note, however, that the very process of manufacture of a forged component tends to eliminate some of the lower end of this tail in that samples which are substantially weaker than the normal will not successfully undergo the forging and manipulation procedures. This does not necessarily apply to castings and one can therefore expect that forging may show an artificial cut-off at the lower end of the scatter band whereas castings may not. This throws into

*Fig. 3 – Frequency Distribution of Rupture Strength of 148 G 18 B Turbine Disks*



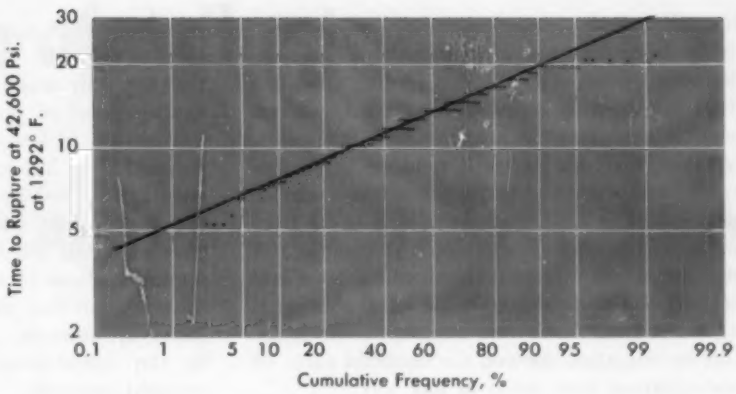



*Fig. 4 – Cumulative Frequency Chart for Rupture Strength of G 18 B Turbine Disks*

relief the importance of developing some form of nondestructive testing of cast components that will eliminate those at the lower end of the scatter band.

The investigations described subsequently do not, however, assume the artificial cut-off at the lower end of the scatter band, and although the body of the results shows a fair agreement with a normal or Gaussian distribution, it is doubtful whether this holds for results at the extreme ends of the band. The statistical technique only assumes Gaussian distribution in order to produce a value which is representative of the scatter to be expected. This value is taken as the $3\sigma$ limit which with such a distribution includes 99.8% of all results, implying that one result in 500 will lie outside of this band.

The type of statistical distribution obtained with 148 rupture tests carried out as a routine check on the quality of solution-treated G 18 B turbine disks is shown in Fig. 3 and 4. The results are shown in Fig. 3 as a histogram on which has been superimposed the calculated normal distribution curve. The same results are plotted on probability paper in Fig. 4. The latter shows how in the middle of the range the distribution is normal; at the high end, there is evidence that unusually long lives are less frequent than predicted and at the bottom end, the lives are somewhat shorter than expected, probably due to nontypical samples either in quality or because of testing technique.

These tests conform approximately to a Gaussian distribution and the width for $3\sigma$ scatter bands corresponds, when calculated in terms of stress, to ± 17%. (It should be noted that in all instances the scatter has been expressed in terms of stress). In this instance, the tests are all taken from a standard position on the turbine disk and are only removed after solution treatment. When tests from disks made all from one heat are considered, this scatter is reduced to ± 12%. The $3\sigma$ scatter bands obtained for various products are shown in Table II.

An examination of the same austenitic steel in the form of solution-treated bar, all from one heat, gave a scatter of ± 12%, and this can probably be taken as typical of a bar material under careful metallurgical control. The results of ten specimens which were tested on the same testing machine showed a lower scatter of ± 6%, but the number of observations is too low to place much reliance on this figure. The same steel tested in the form of warm worked turbine-disk drop stampings from different heats gave a scatter, based on only 11 tests, of ± 20%.

The results of 89 short-time rupture tests carried out as heat-approval tests on a ferritic 12% chromium steel gave a value of ± 40%. This is a surprisingly high value for wrought material

**Table II – Scatter in High-Temperature Products**

| Alloy | Form | Treatment | Scatter in Stress* | No. of Tests |
|---|---|---|---|---|
| G 18 B | Disk forging | Solution treated | 17% | 148 |
| G 18 B | Disk forging | Solution treated | 12 | 85† |
| G 18 B | Disk forging | Warm worked | 20 | 11 |
| G 18 B | Bar | Solution treated | 12 | 22† |
| G 18 B | Bar | Solution treated | 6 | 10‡ |
| H 46 | Bloom | Hardened and tempered | 40 | 89 |
| G 42 B | Blade stamping | Warm worked | 30 | 45 |
| G 34 | Precision casting | As cast | 14 | 46 |
| G 34 | Vacuum casting | As cast | 8 | 16 |

*Scatter of $3\sigma$ limit. †One heat. ‡One heat, one machine.

even though the tests were carried out on relatively large-diameter blooms (about 9 in. in diameter) taken after the first forging operation from the ingot in order to obtain the quickest possible assessment of heat quality. It appears, however, that the scatter is reduced by further mechanical work and that some of the variation may be due to the test pieces not being cut from a standard position in the bloom so that the test may sometimes represent the dendritic zone and sometimes the equi-axed zone of the original ingot. All the tests were from different heats. This investigation showed the doubtful value of heat-approval tests taken in this way.

The results of 45 tests on turbine blade stampings in warm worked G 42 B tested at 1600° F. showed a scatter of ± 30%. This value appears high but lies intermediate between that for solution-treated bars or disks and the heat-approval tests quoted above. It should be noted that this scatter includes not only that due to material of different compositions and from different forging and heat treatment batches, but also covers tests taken from at least three different locations in the blade stamping. Comparable figures do not appear to be available for blade stampings in high-temperature material which has been solution treated and aged, as distinct from warm worked, but it would appear likely that this will give a figure not substantially better than ± 20%.

The scatter in lost-wax G 34 castings cast in clusters around a central feeder has also been studied. A series of specimens was used to determine the expected creep-rupture and hot fatigue characteristics and then the remaining specimens were used for statistical studies. It was found that the scatter between heats was no greater than within a heat, and there was evidence that the scatter was less for the higher temperatures where presumably the greater plasticity would minimize local defects such as porosity or stress raisers. At 1380° F., the $3\sigma$ value in rupture of 46 specimens was ± 14%, which compares quite favorably with the values reported for wrought material.

In an effort to determine the cause of this scatter, it was decided to investigate the properties of a casting made under conditions as nearly ideal as possible. For this, a cylinder was cast of the same composition (G 34) by melting and casting in vacuum into a water cooled steel mold. Test pieces were machined from similar positions round the periphery of this cast test block and investigation of the scatter showed this to be only ± 8%. This indicates the level that could be expected from castings under careful metallurgical control. The investigation also showed that not only was the scatter reduced, but the average level of properties was raised by 14%. The scatter in fatigue strength at 1380° F. was reduced from 33% to 18%, and the mean endurance limit raised by 20%. It is clear, therefore, that the properties of vacuum-cast high-temperature materials may not only be raised substantially above those of conventional wrought materials but that the scatter may even be less. Naturally, however, such a challenge may be met by the introduction of vacuum melting for wrought materials.

**Causes of Scatter**

The above investigation is not complete, but it does indicate gaps in our knowledge of the cause of the scatter observed. These causes may be subdivided as follows:

1. Heat-to-heat or material variables
   a. Analysis
   b. Casting conditions
   c. Deoxidation procedure and inclusions
2. Within one heat or process variables
   a. Ingot number
   b. Position of bloom in ingot
   c. Forging reduction
   d. Forging temperature and amount of reheating required
   e. Heat treatment
3. Structural variables
   a. Position of test piece with respect to original structure of ingot
   b. Direction of test piece with respect to grain flow
   c. Mass effect in heat treatment

It is clear that the effect of heat-to-heat or material variables can be quite low, probably of the order of ± 5% under favorable circumstances. The variables within one heat or within one forging may well be linked with the size of the crystal grains relative to the test piece, the direction of the ingot axis relative to the test piece, and whether the tests have come from the dendritic or equi-axed portions of the original ingot. It is proposed to follow up these variables by an investigation of the scatter in castings, in cast ingots, in blooms and bars of different forging reductions, and within forgings of different shapes, in the expectation that this will lead to such an increase in our metallurgical knowledge that the scatter in properties of a finished high-temperature component can be made both predictable and uniformly low.

# Use of Adhesives for Metal Joining in Germany

*By A. MATTING and E. RUBO**

**Adhesives are not yet used for highly stressed metal-to-metal joints in Germany but their use is increasing as more engineering information about their behavior is obtained. (K 12)**

In Germany, the development of the first usable metal adhesive based on synthetic rubber dates back to the first world war, but adhesive bonding has not as yet attained the same recognition as a high-quality joining method as, for instance, it has in the British aircraft industry. In the first few years following 1945, the use of metal adhesives was almost forgotten. However, after German industry had recuperated somewhat and foreign technical literature had become available without restrictions, the important possibilities offered by the use of such adhesives in construction soon were recognized.

In spite of the great interest, fabricators have been very hesitant to change to adhesive joining of metals and it is used almost entirely for secondary joints. Until a few years ago, foreign adhesives were used exclusively. In the meantime, German manufacturers have placed domestic metal adhesives on the market and among them, a few cold-setting brands have proved to be especially high in quality. The laboratories of the chemical industry developed metal adhesives on the basis of information obtained in connection with the study of other problems, such as boundary-layer phenomena.

The theoretical strength of metal-adhesive joints depends not only on the mechanical bond between the adhesive and component materials but also the atomic processes in the boundary layers. Investigations of the boundary layers with ultrasonic inspection equipment have indicated that there is justification for speaking of a "specific" bond strength of adhesives.

The shear strength of an adhesive joint is also influenced by the surface condition, the curing temperature and the curing time. After the incubation period, the strength increases in relation to the curing pressure, rapidly at first, then slower, to its maximum value which, however, decreases under the influence of service stresses. Changes in the internal stress condition and joint thickness as well as humidity and temperature are contributing factors. The material of construction is also an important factor.

The service stress in an adhesive joint must be below the yield stress of the joined material because the ability of the adhesive layer to yield is always low. Because of the reinforced cross section, the deformation of the adhesive joint upon the application of failure load may be less than that of the surrounding sheet and the part will fail outside the joint if the overlap is sufficiently long.

In testing metal adhesives, it became evident that the strength of the adhesive joint is affected to a considerable extent by the form of the clamped end of the specimens. Usually, the sheared strips are first joined together and then provided with a reduced test section by the milling of both edges. Under all circumstances, the highest strength values are obtained when machining of the adhesive joints is avoided. Therefore, mechanical work after joining should

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**Table I – Mechanical Properties of Adhesive Joints in Hardened Aluminum Alloys**

| | Tensile-Shear Strength* | Fatigue Strength* ($5 \times 10^7$ Cycles) | Impact Strength† | Tensile Strength* | Peeling Strength‡ |
|---|---|---|---|---|---|
| | | Hot-Setting Adhesive | | | |
| Approximate range | 1150-7000 | 300-1150 | 3-35 | 7000-13,000 | 0.8-3.0 |
| Nominal value, single lap | 2100 | 400 | 5 | 10,000 | 1.2 |
| Nominal value, double lap | 3500 | 800 | 20 | — | — |
| | | Cold-Setting Adhesive | | | |
| Approximate range | 400-2100 | 70-600 | 2-15 | 4000-7000 | 0.3-0.8 |
| Nominal value, single lap | 600 | 150 | 3 | 5500 | 0.5 |
| Nominal value, double lap | 1200 | 300 | 10 | — | — |

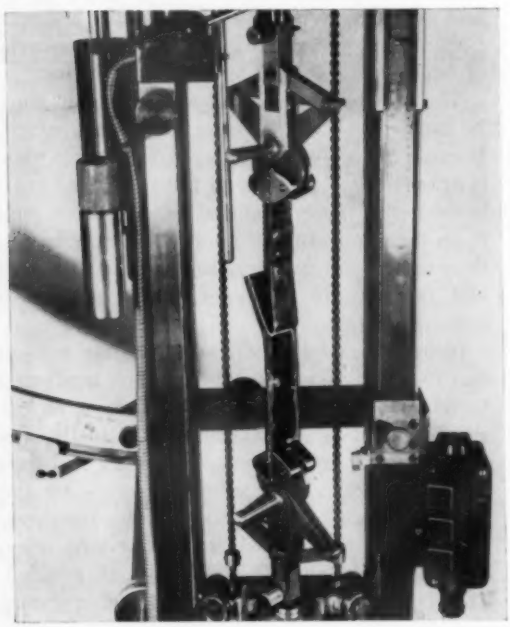
*Lb. per sq.in. of adhesive area †Ft-lb. per sq.in. of adhesive area ‡Lb. per in. of lap width

be limited regardless of the advantages which might have been gained. The waist-like reduction in the prismatic test coupon cannot be dispensed with in the testing of high-quality adhesive joints, since fracture otherwise, especially in fatigue tests, might emanate from a clamped end and invalidate the test result.

Some of the test results are shown in Table I. The peeling strength was determined by the rolling apart of two aluminum foils which had been glued together, as shown in Fig. 1.

An essential objective of testing the strength of metal adhesive joints was to furnish basic design data. The Institute for Processing of Plastics of the Aachen Engineering School has devoted itself to this task. Its methods of calculation are based on the optimum strength values obtained in a testing machine which, however, never are obtained because of the harmful secondary influences which operate on structural parts. Allowance is made for these harmful influences, such as the effect of humidity, by an efficiency factor similar to that used in calculating the strength of weld joints. For each individual set of conditions, the expected strength of the adhesive joint is obtained by multiplying the optimum strength value by the efficiency factor. The determination of these factors is possible only on the basis of a statistically adequate number of test results and, therefore, is still in the preliminary stage.

*Fig. 1 – Method of Evaluating Peeling Strength of Adhesive Joints*



Several adhesives tested for corrosion resistance were found to be appreciably sensitive to water. For applications in a humid environment, therefore, effective edge protection against the penetration of moisture is indispensable. In dental applications, experiments with adhesives have been unsuccessful because of the low resistance of the adhesives to saliva.

In order to make the adhesive joints amenable to nondestructive testing, highly opaque substances were added to make the adhesive visible on X-ray films or on the fluoroscope screen. In this way the distribution of the adhesive inside the joint could be successfully checked. The perceptibility of the adhesive in layers of conventional thickness was in direct proportion to the amount of the addition agent. The additive was red lead. Large additions lower the strength of the adhesive joint; however for additions up to 20% by weight, an increase in static strength of about 15% was observed.

A disadvantage of the X-ray method is that the separation of the adhesive from the sheet cannot be recognized. Such defects, which arise from time to time in production, can sometimes

*Fig. 2 – Adhesive-Bonded Magnet System Tested by Resonance*

be discovered through ultrasonic testing, although this is not being done in Germany.

In special applications, such as the adhesive-bonded magnet system shown in Fig. 2, it was evident that resonance upon striking the assembly with a light hammer distinguished between perfect points and those containing unbonded sections. The former produce a loud ring whereas the latter produce a dull, damped sound.

An important question is the optimum length of overlap in an adhesive joint for maximum strength. Investigations conducted with both static and alternating stress indicated very little difference in results. As a rule of thumb the lap should be 20 to 25 times the sheet thickness. Investigations by E. Rubo and H. Reiche with repeated impact indicate a similar relation.

There are three major obstacles to the introduction of adhesive joining techniques:

1. The relatively long curing time for metal adhesives, especially the cold-setting resins.

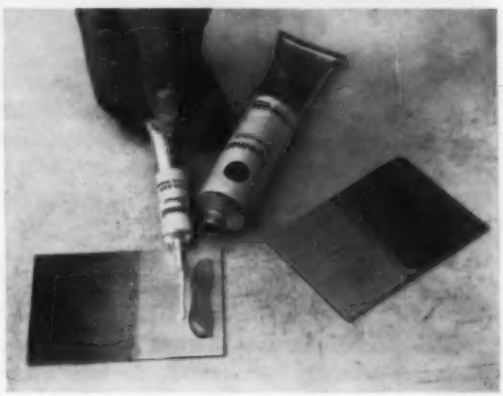
2. The high investment required for heating and pressing equipment used for high-quality hot-setting metal adhesives. In Germany, these costs are more important than in America because German manufacturers cannot expect as great a volume of production.

3. The great sensitivity of adhesive joints to bending because of their low peeling strength.

These deficiencies may be overcome by bracing the metal adhesive joints with auxiliary fasteners to prevent them from being torn asunder. Under these circumstances, the transient unstable condition of the adhesive joint in the assembly is no longer an obstacle. Rivets, screws and resistance welds are used. Resistance welds may be produced through the adhesive when the latter is still in the fluid condition. However, the fatigue strength of such combined adhesive joints is lower than that of the adhesive alone. For this reason, in the British aircraft industry, auxiliary rivets are removed after the adhesive has set. The cause of the lowered endurance strength is the different stiffness of the adhesive and auxiliary fastening. A resistance weld is less resilient and, therefore, takes the major portion of the load in an adhesive joint with resistance welds. The combined joint, therefore, is only a little more resistant than the resistance weld alone. To increase the load-carrying capacity of the combined joint, elastic auxiliary members have been proposed. Hollow rivets, especially when countersunk, have proven very suitable.

Two-component adhesives are produced by mixing the adhesive and the hardening agent in prescribed proportions prior to their application. Proportioning is accomplished either by weighing the components or by packaging them in containers of different sizes. In the latter instances, correct proportions are obtained when the entire contents of both packages are mixed together. The first method is more elaborate; with the second procedure, greater quantities of adhesive must be used in a shorter time since the adhesive, after the addition of the hardener, has only a very short shelf life. In this respect, the method adopted by one German manufacturer who delivers the two components separately in two tubes, is helpful. The high-viscosity com-

*Fig. 3 – Two-Component Adhesive Packed in Separate Tubes to Facilitate Mixing*



ponents are squeezed out of the tubes to form two separate blobs whose individual volumes should be in a definite ratio to each other as indicated in Fig. 3. The blobs are mixed and the adhesive is ready for use. This method of measuring is most useful in making repairs.

Metal adhesives are furnished with various viscosities. Low viscosity is desired when large surfaces are to be treated. High-viscosity adhesives are preferred for close-fitting joints.

As to the practical application of metal adhesives, no use as impressive as their application in British production can as yet be mentioned. Instead, the trend is to verify the production application of the new joining method on small units and in low-stress components.

Aluminum furniture was one of the first products joined by adhesives. The corner of an adhesive-bonded chair is shown in Fig. 4. In brakes which are not exposed to the danger of running hot, the brake bands are attached with adhesive instead of being fastened with copper rivets, as shown in Fig. 5. The brake bands may be worn thinner and a greater proportion of their thickness can be used. Motor bike frames made of Silumin are an example of the use of metal adhesives in volume production. On the frames, the tank supports are fastened to the tank cover and this in turn to the cast casing by means of metal adhesive. Finally, the threaded gasoline drain cock is secured against loosening by the same cold-setting adhesive.

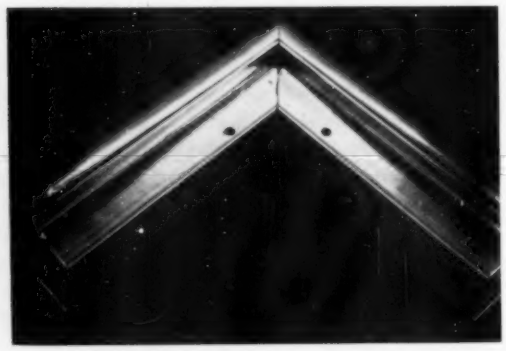


*Fig. 4 – Corner Section of Adhesive-Bonded Aluminum Chair*

*Fig. 5 – Brake Shoes With Adhesive-Bonded Brake Band*

Worth mentioning also are the efforts to produce lightweight building panels through the use of metal adhesives. For construction similar to "sandwich" and "honeycomb" building methods employed in England, a German firm is investigating the suitability of corrugated sheet as an insert between external aluminum skins as shown in Fig. 6.

*Fig. 6 – Sandwich Structure With Core of Corrugated Sheets*

In one interesting application, holes had to be drilled in an air duct made of sheet metal pipe in order to study the gas flow. Upon the completion of the investigation, the holes were closed with sheet patches fitted to the pipe wall and attached by means of an adhesive. The necessity of shutting off the air was thus eliminated. In order to counteract the air pressure in the duct (which ,of course, was low) the patches were pressed lightly against the pipe by securing them with baling wire until the adhesives had set.

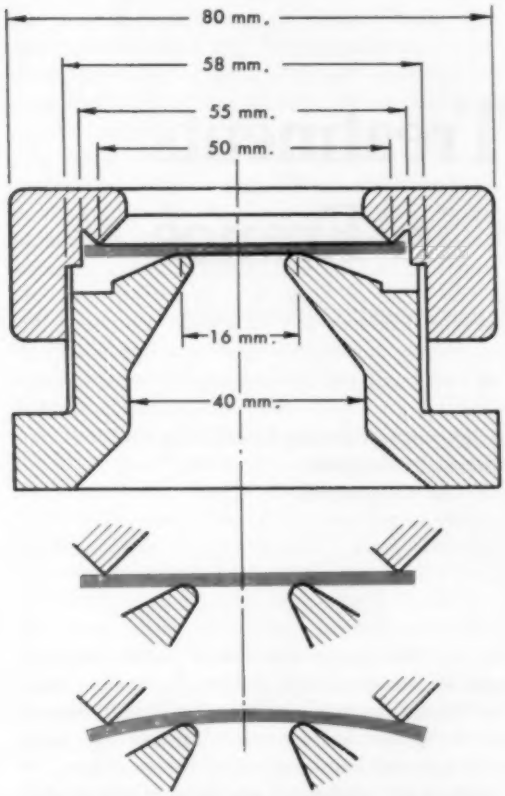
The novelty of metal-adhesive joining in industrial fabrication is a compelling reason for critical evaluation. In Germany, there is much development work and a few applications of metal adhesives in production; the number should increase rapidly in the future.

# Influence of Residual Stress on Hardness

*By P. A. BLAIN**

**True hardness is a measure of resistance to impingement rather than the resistance to penetration now determined in "hardness" testing. (Q 29)**

THE CLASSIC DEFINITION of hardness is "that property of a body by which it resists the pressure of other bodies that impinge upon it, and the degree of hardness is measured by the quantity of this resistance". Conventional measurements of "hardness" measure not resistance to impingement but resistance to penetration.




*Equipment Used for Hardness Determination*

Hardness should be expressed as the maximum pressure which can be applied locally to a specimen without causing plastic deformation. This definition, which is analogous to that of the elastic limit in the tensile test, is much more practical; when an alloy of great hardness is used in a machine, it is supposed to resist high local pressure without giving way to the slightest plastic deformation.

Once this concept is admitted, it is easy to understand that, following the laws of plastic flow, the hardness of a specimen is the result not only of the analysis of the material and its state of heat treatment or of cold working but is also influenced by the direction and the magnitude of the stresses which exist in its external layers.

I demonstrated this fact many years ago with the following experiment:

A disk, 55 mm. in diameter and 1.5 mm. thick, of a hypereutectoid steel is tightened between two parts of the apparatus shown in the sketch. One part presses on the disk with a ring 50 mm. in diameter and the other part supports the disk with a ring 16 mm. in diameter. The pressure of the two rings is applied to the disk by tightening the apparatus, and the disk becomes dish-shaped. This means that the convex surface of the disk is under tension while the concave surface is under compression. At the center of the disk the hardness may be measured on both surfaces.

The test specimen is highly polished and submitted to the pressure of a perfectly polished ball. The pressure is gradually increased and observations made after each test to see if the ball has left an indentation. This can be ascertained by observing the reflection of light on the

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polished surface of the test piece. When the maximum force which can be applied without causing permanent deformation has been determined, the maximum pressure in the contact circle may be calculated with the aid of Hertz's formula for the contact pressure between a plane and a sphere. The formula is:

$$\sigma = \frac{1}{\pi}\sqrt[3]{\frac{3}{2} \cdot \frac{P E^2}{(1-m^2)^2 r^2}}$$

in which $\sigma$ is the maximum pressure in the contact circle; P, the load; E, the modulus of elasticity; m, Poisson's ratio and r, the radius of the ball. If the value of E is taken as 21,200 kg. per sq. mm. for 100% elongation, m as 0.33 and r as 5 mm., then:

$$\sigma = 103\sqrt[3]{P}$$

The maximum load that could be applied to the flat disk without causing deformation was 35 kg., so that substituting 35 for P in the above formula, $\sigma$ is equal to 337 kg. per sq. mm. When the disk was dished 1.5 mm. to produce a surface stress on the convex side of about 165 kg. per sq. mm., the maximum load on the ball that did not cause additional deformation of the convex surface was 0.75 kg., equivalent to a pressure of 95.4 kg. per sq. mm. On the concave surface, the maximum load was 130 kg., equivalent to a pressure or true hardness of 515 kg. per sq. mm.

Thus, the true hardness of this steel can vary fivefold under the influence of surface stress of about 165 kg. per sq. mm. in the region being tested. This difference cannot be detected by the penetrator method of hardness measurement. Using a Rockwell machine, the hardness of the disk before deformation was C-50. The hardness of the elastically deformed disk was C-49 on the convex side and C-52 on the concave side.

# Use of Isothermal Heat Treatments in France

*By GEORGES STEMPFEL**

**The lack of free interchange of technical information during World War II retarded the development and use of isothermal treatments in France but they are now in widespread use. (J general)**

ISOTHERMAL HEAT TREATMENTS were first described in research reports in about 1930 but it was several years before the laboratory research was translated into commercial practice. This evolution was about the same in all countries; the only difference was that it could be more rapid in countries with powerful means of production and research such as the United States, but slower and less sensational in countries such as France, still handicapped by the war years.

Isothermal treatments are those in which austenite is transformed at a constant temperature

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below the $Ae_1$ temperature. The treatment consists of austenitizing followed by cooling rapidly enough to suppress any transformation between the temperature of austenization and the temperature of the cooling bath. The cooling which follows the isothermal transformation does not induce any additional structural change. The final structure depends on the temperature of the isothermal transformation.

Isothermal annealing is used to obtain a softened ferritic-pearlitic structure.

Austempering is used to obtain an acicular structure – bainite.

**History of Martempering**

Martempering consists of cooling rapidly enough to suppress transformation before a temperature near and, if possible, a little above the martensitic transformation is reached. The steel must be held in the quenching medium long enough for the whole mass to reach this temperature, after which the piece is cooled in air. It is during this latter cooling that the austenite is changed into martensite. Properly speaking, this is not an isothermal transformation. However, this process, which was developed during the same investigations that led to isothermal treatments, is related to such treatments and has become so important that it cannot be omitted from this discussion.

As far as we know, we were the first to use martempering for constructional steels and for certain toolsteels. This was in the heat treating department of the Electrochemical, Electrometallurgical and Electrical Steel Co. of Ugine. The first quenching unit, used in 1934, was a salt tempering bath with the standard mixture of nitrates and nitrites of sodium and potassium. It was heated by gas and at first there was no system for cooling the bath.

At that time, an analogous process for tempering high speed steels had already been in use for a rather long time; it consisted of rapid cooling from the austenitizing temperature to around 550° C. (1020° F.). The steels were quenched by immersion in a bath of molten lead. Since the practice of heating high speed steels in a salt bath before tempering became prevalent, this lead cooling bath has been replaced by salt baths. Treatment of high speed steels is so near the definition we gave for martempering that we have kept the same designation for this treatment. So, martempering was already applied to high speed steels before the first publications on isothermal treatments. However, there is no doubt that this lead treatment was little used and that it was finally due to the publicity about martempering for constructional steels that martempering of high speed steels became the standard practice it is today.

During the period from 1934 to 1939, martempering was rapidly adopted for the treatment of high speed steels, more slowly for constructional steels. Interest aroused by publications on isothermal transformation curves did not diminish during this period; quite the contrary, the principal steel works and the large schools and universities installed equipment for the study of isothermal transformation phenomena, and many practical applications were developed. Numerous martempering tests had been conducted during the years before the war, especially in the automobile industry and certain branches of armament.

During the war years, 1939 to 1945, and the years that followed, money and raw materials were short and this had a two-fold effect on the development of isothermal treatments.

We were unable to exchange technical information with other countries and the lack of foreign scientific publications slowed up both theoretical and practical development. In addition, many engineers and technicians were either in prison or in hiding. The big steel plants could not consistently produce steels constant in composition and quality; their supplies of raw materials were much too irregular. Because of this, even where theoretical knowledge was advanced, it was impossible, for example, to set up an austempering cycle on a production line because such an operation would require steels of a constant and continuous quality.

On the other hand, shortages of raw materials contributed to the greater usage of martempering. Petroleum-base mineral oils are the basis of all good tempering oils and these oils were completely unavailable. On the other hand, nitrates and nitrides, although relatively rare, could be obtained in France. Martempering bypassed oil tempering completely by replacing it with tempering in a salt bath heated to about 180 to 200° C. (360 to 390° F.). More than one firm was thus forced to martempering sooner that they would have made the change under normal conditions.

After the war, France was severely handicapped because the isothermal transformation curves of French steels were unknown, so that it was very difficult to perfect what could properly be called an isothermal treatment.

Table I – Composition of Salt Mixtures Used in France

| Type | Melting Point | | $BaCl_2$ | KCl | NaCl | NaCN | Others |
|---|---|---|---|---|---|---|---|
| A | 950 °C. | 1740 °F. | 98% | — | — | — | — |
| B | 670 | 1240 | 50 | — | 50 | — | — |
| C | 650 | 1200 | — | 50 | 50 | — | — |
| C-1 | 650 | 1200 | — | 45 | 45 | 10 | — |
| D | 540 | 1000 | 40 | 30 | 30 | — | — |
| D-1 | 540 | 1000 | 37 | 29 | 29 | 5 | — |
| E | 440 | 820 | 30 | — | 25 | — | 45 $CaCl_2$ |
| F | 450 | 840 | — | — | — | 65 | 35 $Na_2CO_3$ |
| G | 350 | 660 | — | — | — | 50 | 50 KCNO |
| H | 140 | 280 | — | — | — | — | 55 $KNO_3$, 45 $NaNO_2$ |

Fortunately, during the past few years we have caught up; many publications indicate the scientific activity of the country in the field of isothermal treatments. Most of the steel producers and professional organizations, such as IRSID (Research Institute for Ferrous Metallurgy), have published isothermal transformation curves for French steels.

### Compositions and Uses of Salts

At the present time, there are about 500 salt bath furnaces for isothermal heat treatment in France with a total volume of 7000 cu.ft. Between 800 and 900 tons of salts were consumed in their operation in 1954 and about 1100 tons were used in 1955. Most of the steel quenched in these salt baths is also austenitized in salt baths. The compositions of the salt mixtures used are shown in Table I.

**High speed steels** and hot work die steels which are to be martempered are austenitized at 1000 to 1300° C. (1830 to 2370° F.) in Type A salt. Its decarburizing action is neutralized by additions of products derived from boric acid or fluorides or by silica. For austenitizing temperatures near 1000° C. (1830° F.), the melting point of the bath is lowered by additions of sodium or potassium chloride.

Type E salt is usually used for martempering and the temperature of the bath is maintained at about 550° C. (1020° F.). Types F and G are also used in martempering but not for high speed steel tools because of the nitriding effect of the cyanides. Nitrate-base salts (Type H) are used rarely – for example, for high speed steel tools whose points only are treated, such as the cutting edge of a mining drill.

**Nickel-chromium** and nickel-chromium-molybdenum air hardening steels used for structural applications and for plastic molds are usually austenitized in Type B, C or D salts at 840 to 880° C. (1540 to 1620° F.). Occasionally these steels are case hardened during austenitization by using Type C-1 or D-1 salts.

It should be emphasized that an explosion can result in a nitrate martempering bath (Type H salts) if the sodium cyanide content is greater than 10%.

Type E salts are used at 550° C. (1020° F.) for martempering these steels. Molds whose surfaces must be free from flaws are martempered in Type F or G salts because they are very deoxidizing and eliminate every trace of oxidation. A special technique used for molds is to keep them in the Type F or G martempering bath for an hour or more so that a nitrided case will form. The austenite is stable at this temperature and the core transforms only during subsequent cooling so that the core will be completely martensitic and the nitrided surface will be very resistant to wear.

**Other structural steels** and toolsteels are austenitized in Type B, C or D salts. The martempering bath is usually Type H and is held at about 200° C. (390° F.).

All steels to be austempered except the high speed steels are austenitized in Type B, C, C-1, D or D-1 salts. The quenching and austempering bath is usually Type H. The temperature depends upon the composition of the steel and the properties desired and varies between 250 and 500° C. (480 and 930° F.).

**Carbon and low-alloy steels** are isothermally annealed by quenching in a salt bath at 650 to 680° C. (1200 to 1260° F.) and holding at that temperature for several hours. The austenitizing baths are usually Type B, C or D. Components which must be case hardened and annealed are austenitized in Type C-1 or D-1 salts.

The annealing baths are either Type D or E. If a cyanide bath is used for austenitizing, Type D is preferred because the calcium chloride in Type E salts reacts with cyanides to form a lather which will overflow.

# Recent Uses of Radioactive Isotopes in Britain

By JOHN F. CAMERON*

**Difficult problems in thickness gaging have been solved with instruments using beta rays and the backscattering of gamma rays, Trace impurities are estimated by irradiating the sample and measuring the induced radiations and their rate of decay. (S 19, S 11, S 14)**

ARTIFICIAL RADIOACTIVE ISOTOPES have been available in Britain since the Harwell reactor nicknamed BEPO started operation in 1947. While the basic principles of the applications of radioactive isotopes remain the same, the field of application continues to broaden and now covers almost every branch of the ferrous and nonferrous industry. These will now be described briefly.

### Economic Geology

With the advent of atomic energy the delineation and estimation of the earth's uranium and thorium content has become of prime importance. Because of their natural radioactivity this work is greatly facilitated, and at Harwell instruments have been designed and constructed for their detection and estimation.

When the terrain is covered with a good network of unpaved roads, a rapid survey can be undertaken in a motor car by scintillation counter equipment. This survey can indicate areas which are likely to merit detailed investigation with portable instruments and can also be used for geological mapping. Surveying from the air in light aircraft with sensitive scintillation equipment is used for similar purposes. Areas of interest are located by flying at 500-ft. elevation along lanes of about 1000-ft. spacing.

Small transistor operated rate-meters powered by three 1.5-v. dry cells with Geiger and scintillation detectors are the principal tools of the field geologist, the mining engineer and the prospector, and are designed to give reliable service even under extreme weather conditions and hard usage. These units, in conjunction with auxiliary probes, can be used above and below ground for estimating the size of ore bodies, for locating small pockets of active material, and also for borehole logging. One type of detecting unit using a halogen-quenched Geiger counter, and giving both visible and audible indication of the gamma ray flux, weighs only 1 lb. and is small enough to go into a man's pocket.

Borehole logging equipment, in conjunction with exploration drilling, is used for detecting radioactive ore and for mining control. Pulses from halogen-quenched Geiger counters are fed along armored coaxial cable, with little loss, by pulse transformer matching circuits. Fully sealed detecting probes as small as 0.75-in. outside diameter can log down to depths of 1500 ft.

The ore selector shown in Fig. 1 can distinguish the quality of radioactive ore, tramcar by tramcar, according to whether the average grade is above or below a given level. It consists of several long Geiger counters held in a frame, and connected in parallel to a rate-meter fitted with a relay.

### Ventilation

The dispersion of gas and dust of respirable size, which takes place by turbulent diffusion, has been studied by J. R. Hodkinson of the Safety in Mines Research Establishment by radioactive tracer methods. Methyl bromide ($CH_3Br$) labeled with $Br^{82}$ is used as the tracer. Sampling is done by drawing the air through an array of tubes and absorbing the methyl bromide on granulated charcoal which is subsequently assayed with a scintillation counter.

The measurements lend support to the theory that the transverse diffusion pattern in a straight, unobstructed duct or gallery is independent of

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air speed, and that the distance for complete mixing is 30 to 50 diameters. When mixing may be incomplete, sampling at a position 0.6 of the distance from center to wall gives the best probability of estimating the mean concentration. An opinion has been expressed that the only accurate means of measuring true mean air-flows is by radioactive tracer techniques (either by measuring the mean speed of travel of a pulse of tracer or the dilution of a continuously released tracer).

### Thickness Gages

Gaging instruments are in general use in Great Britain which depend on a radioactive isotope as a source of radiation and a suitable detector to measure the scattering or absorption of these radiations by matter, or the residual strength of the stream after penetration. One big advantage of such gages is that no contact is necessary with the material being measured.

**For Process Control** – The basic principles of these instruments are now well understood and the feasibility of a particular gage for any particular requirement can be estimated. The main difficulties nowadays arise in the engineering of gages which have to operate under adverse conditions such as high temperatures, vibration, the presence of dust, oil and other vapors, the scanning of the transverse profile of continuously produced materials, and automatic standardization by introducing standard thicknesses of materials at suitable intervals. All these involve major engineering problems, but the difficulties are rapidly being overcome by combinations of electrical, mechanical, hydraulic and pneumatic devices.

A wide variety of radiation detectors – Geiger, proportional, scintillation with photocell or photomultiplier, ionization chamber – are employed, each where best suited. Now that *bremsstrahlung** and beta-excited X-ray sources are in use to cover the awkward range between the hardest beta radiation and the softest gamma radiations, radioactive sources are available which are suitable for thickness of metal from very thin foil to several inches of steel.

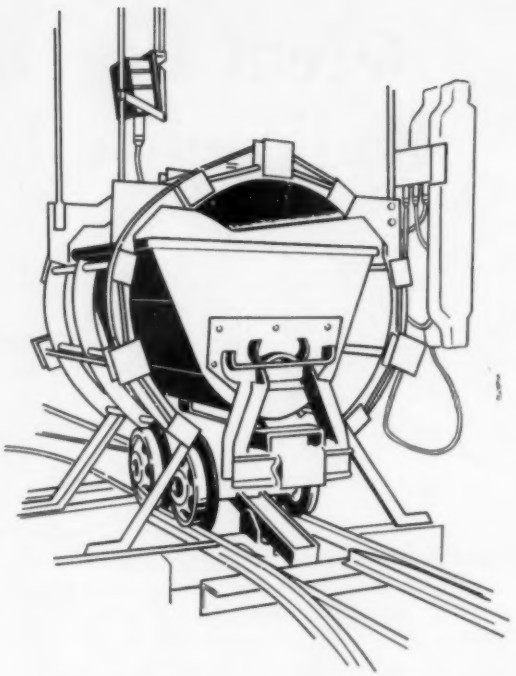


*Fig. 1 – Sketch of Cradle Carrying Nine Long Geiger Counters Which Estimate Average Grade of Radioactive Ore in Tramcar*

Beta-ray thickness gages, which have been installed in a tin-plate works for measuring continuously rolled steel sheet in the 0.005 to 0.025-in. range, give an accuracy of ± 0.00005 in. with a time constant of 0.05 sec. Drift on these instruments in one week may amount to 0.00002 in. The gage uses 100 millicuries of strontium-90 plus yttrium-90 as the source and an air-filled ionization chamber as the detector. A "balancing" ionization chamber with a smaller source is fitted with a grid on which the potential is varied so the mean current in the measuring chamber can be backed off. This gridded ionization chamber considerably simplifies the design and has been patented by E. B. Bell of Isotope Developments Ltd. Air jets remove interfering palm oil films from the steel and from the chamber window.

In measuring the thickness of continuously rolled strip one of the major difficulties comes from the "whip" of the metal as it passes from one stand to the next. This is avoided by the scheme sketched in Fig. 2, a gamma ray back-

*This definition of *bremsstrahlung* is taken from "A Glossary of Terms in Nuclear Science and Technology", published by the American Society of Mechanical Engineers:

BREMSSTRAHLUNG – The production of electromagnetic radiation by the acceleration that a fast charged particle (usually an electron) undergoes when it is deflected by another charged particle (usually a nucleus). The spectral distribution is continuous, the well-known X-ray being a prominent example. For very energetic electrons (above about 50 Mev.), the energy loss by radiation far exceeds that by ionization as a stopping mechanism in matter; this process is sometimes called *outer* bremsstrahlung to distinguish it from *inner* bremsstrahlung.

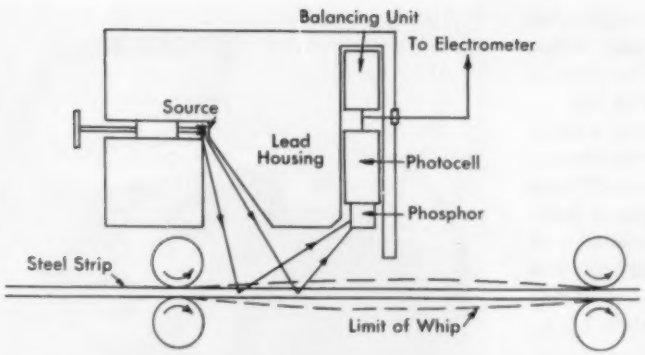



*Fig. 2 – Diagram of Gamma-Ray Backscattering Device for Gaging Thickness of Steel Sheet and Strip Under Rapid Movement and More or Less "Whip"*

scattering gage for measuring steel up to 0.5 in. thick. The radiation from a 1-curie source of cesium-137 (held in a massive lead housing and completely shielded when not in use) is scattered back onto a detector consisting of a 1-in. cube of sodium iodide and a photo-electric cell. The current in the photocell has a linear relationship to the thickness of the sheet up to 0.25 in. and the variation in backscattered gamma ray intensity for a "whip" of ± 0.5 in. corresponds to a variation in thickness of only 1% of the basic weight. A small gridded ionization chamber measuring the beta radiation from a thin cesium metal foil is used for backing off. Temperature is stabilized by a thermistor.

Another instrument, under development, is for measuring the diameter of continuously extruded steel bars. A source of beta radiation passes through a slit, in front of which runs the bar. The amount of radiation reaching the ionization chamber detector on the other side of the slit is then independent of the position of the bar within the limits of the slit but depends directly on its cross-sectional area.

G. Syke of the Baldwin Instrument Co. has described a gamma-ray thickness gage used on hot rolled steel strip 0.05 to 0.30 in. thick. A 500-millicurie source of thulium-170 is employed. The detector consists of a sodium iodide crystal and photomultiplier on a shockproof mount inside a water-jacketed steel container. With an integrating time of 1.6 sec. an accuracy of 0.4% is obtained. When the source is mounted on the end of a steel rod and the tube is threaded over this while rotating in a cradle, the instrument can measure the wall thickness and also any eccentricity of red hot steel tubes 2 to 6 in. in bore and 0.1 to 0.6 in. wall thickness.

A gage similar to this, but with a 1-millicurie strontium-90 plus yttrium-90 source of beta rays and a thin plastic scintillator, has been used to measure the thickness of 12-ft. lengths of steel tubing 0.5 to 1.5 in. ID and 0.018 in. wall.

Sorting of steel sheet according to the total mass per unit area is done in the tin-plate industry with the help of a beta-ray with a short time constant. Sheets traveling at 300 ft. per min. and differing at any point of their length by more than 1% of the total mass per unit area can be sorted with such a gage plus a storage device with variable memory. It is intended to develop the instrument so it will sort sheets traveling at 2000 ft. per min.

A recently developed backscattering gage, shown diagrammatically in Fig. 3, utilizes the degradation in energy which takes place when gamma rays are scattered through a large angle.

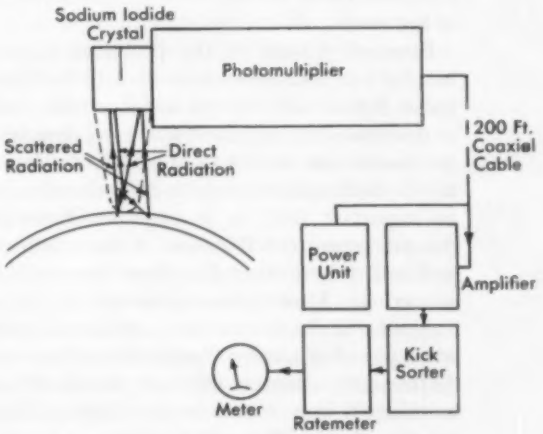



*Fig. 3 – Diagram of Backscattering Gage for Measuring Wall Thicknesses From 0.10 to 0.75 In.*

The detector is a scintillation counter and a simplified kick-sorter selects pulses only of the amplitude corresponding to the reduced energy of the scattered radiations. Direct radiations from the source to the detector can thus be rejected and only the scattered radiations which are a function of the thickness of the scattering material are recorded. There is no screening between source and detector so the measuring equipment is light and portable. Since a very small source (20 microcuries) is required, there is no radiation hazard. Figure 4 shows the complete equip-

ment. The circuits are sufficiently stable that dependable measurements can be made within ± 4% over a thickness range of 0.10 to 0.75 in., using the integrating time constant of 10 sec.

**Maintenance** – Wear on the plates in a large coal hopper has been measured by a novel technique. A 1-millicurie source of thulium-170 was collimated in a small lead holder to give a beam 0.06 in. in diameter, and held up to one face of the hopper by a small permanent magnet. The number of gamma rays penetrating the steel was measured with a crystal of sodium iodide 1.5 in. diameter by 0.062 in. thick, a scintillation counter placed in contact with the opposite face of the steel sheet, and a rate-meter. The rate-meter output was electrically backed off and the out-of-balance current indicated on a small meter fixed to the measuring head. Rough alignment was obtained by measurement from the hopper edges and exact alignment obtained on the meter fixed to the scintillation counter. Calibration was done with steel shims. The plates were a nominal 0.44 in. thick and an accuracy of ± 0.002 in. was obtained in about 1 min. Variations in thickness were found to correlate with the known path of the coal.

**Research** – Many of the problems in metallurgical research are concerned with the flow of gases, liquids and slurries under a wide variety of conditions; temperature, flow rate, density and composition are among the quantities to be measured. Radioactive isotope techniques often play an important part, as in experiments on heat transfer where the thickness of the conducting wall had to be measured at places inaccessible to calipering. Density measurements on the settling rates of slurries and the particle distribution when pumping around closed circuits have used thulium-170, strontium-90 and yttrium-90 with scintillation detectors. In the study of liquid metal coolants, irradiated materials and gamma radiography are used to measure solubility.

The natural activity of some metals is sometimes utilized. For example, the gamma radiation from thorium is used to trace thoria in experimental rigs. The thickness of the aluminum or beryllium cladding on uranium fuel elements has been measured using the absorption of the 2.32-Mev. beta particles from the protoactinium-234 in equilibrium with the uranium-238 in the fuel elements; a beta counter scans the surface of the element and the count rate in the detector is a function of the thickness of the cladding. An estimate can also be made in this manner of distribution of protoactinium-234 in a composite fuel element.

*Fig. 4 – Complete Portable Equipment of Fig. 3. Radioactive source is so small it requires no shielding*

### Gamma Radiography

The use of gamma-emitting radioactive isotopes has several advantages over conventional X-ray tubes for radiography. These sources are small, relatively cheap, and do not need external power supplies. Thus they are ideal for firms producing small numbers of objects which need to be radiographed, and they can be used in the field and other places such as in shipyards and inside intricate castings inaccessible to million-volt machines.

Trends are toward sources of higher specific activity and this demand will be largely met when the high flux in Harwell's DIDO reactor becomes available.

At present, pile-produced iridium-192, cobalt-60 and thulium-170 and the fission product cesium-137 are the sources most widely used. Several British firms market such elements in

**Table I – Radiographic Source Production at Harwell**

| Source | Sources Dispatched per Year | | | | Equivalent Curies | | | |
|---|---|---|---|---|---|---|---|---|
| | 1952 | 1953 | 1954 | 1955 | 1952 | 1953 | 1954 | 1955 |
| Iridium-192 | 650 | 901 | 1295 | 1361 | 810 | 2099 | 3489 | 4850 |
| Cobalt-60 | 231 | 228 | 201 | 414 | 110 | 185 | 213 | 600 |
| Thulium-170 | 0 | 28 | 43 | 43 | 0 | 10 | 9 | 7 |

containers varying from comparatively simple ones to elaborate remote control arrangements. Generally they are used for inspection of weldments or castings.

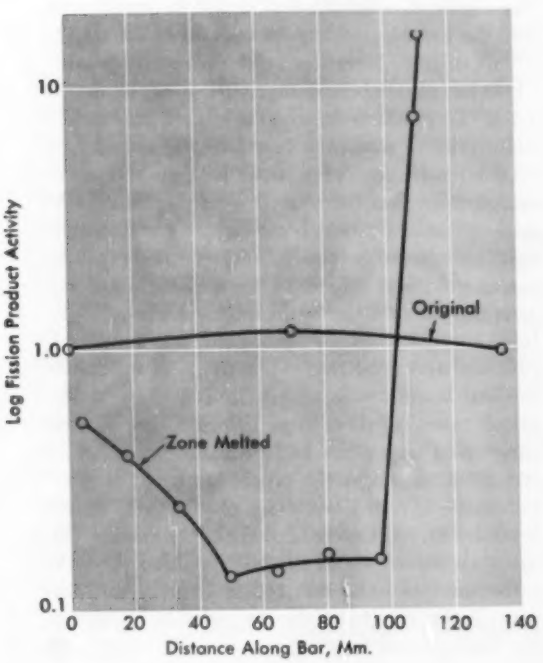
The number of sources produced by pile irradiation in the United Kingdom during the past three years is shown in Table I. They have been sent to 21 countries, and it is believed that the output exceeds that of any other country.

### Efficiency of Zone Melting

Reactor fuels have to be processed by chemical separations at regular intervals for various reasons, one of which is to remove fission products which capture many neutrons. A simpler and cheaper way of removing fission products from irradiated fuel elements would be of great value and recent work at Harwell by J. E. Antill on the zone melting technique shows considerable promise.

Metallic solutions of cobalt in uranium, and ruthenium in uranium, were studied using the gamma-emitting isotopes $Co^{60}$ and $Ru^{103}$. After zone melting, transverse slices of the bars 1 mm. thick were cut and counted. Since uranium is one of the densest elements it was thought that specific gravity differences might be used to increase the separation. The results obtained for uranium containing 800 ppm. ruthenium when the zone was passed upward and downward at 0.25 in. per hr. prove that even for soluble impurities at low concentrations, density effects can be used with advantage. Uranium bars irradiated in a neutron flux of $2.5 \times 10^{10}$ neutrons per sq. cm. per sec. for 5 hr. and cooled for 8 days have been zone melted, passing the zone upward at a speed of 3 in. per hr. The result of this purification measured by the total gamma activity filtered through 0.024 in. of lead is shown in Fig. 5.

*Fig. 5 – Purification by Zone Melting of Uranium Bar From Its Fission Products*




### Wear Studies

Studies are being made in Great Britain both of the nature of the changes which a surface undergoes during wear, and of the amount of material removed.

In measurements of wear it is necessary to study quantitatively some physical processes which occur on a very small scale. Such measurements are greatly facilitated by the use of radioactive isotopes. In frictional studies, if one of the rubbing surfaces is radioactive, then any metal particles transferred from it can be measured with some type of counter which estimates the amount of radioactivity on the inactive surface, and the distribution of such particles over the area of contact can be obtained by exposure to X-ray films. If one component of a lubricated mechanism is radioactive, then the amount of radioactivity which appears in the circulating lubricant is derived solely from the wear of that component.

Several laboratories in Britain are equipped with the necessary facilities both for handling the highly radioactive components and for detecting the minute amounts of material which are transferred. Alexander Duckham & Co. Ltd. has set up a laboratory in which radioactive cutting tools are used for research into tool life, cutting fluids and machinability. The tool tips of "Wimet X-8" (tungsten carbide 77%, cobalt 8%, titanium carbide 15%) were irradiated in BEPO one week to give a total of 15 millicuries per g. These tools give 80 min. cutting time per tool edge under standard conditions, and since 6 to 10 sec. is sufficient to give about 50 g. of chips, 500 tests could be run for each set-up. It was found that 95% of the products of tool wear are embedded in the chips. With the 50-g. samples in a fixed geometrical relation to a scintillation counter, the counting rates from the samples were from 3 to 5 counts per sec.

Tests are being conducted on the mechanism of wear and the efficiency of lubricants in several laboratories, including those of Associated Elec-

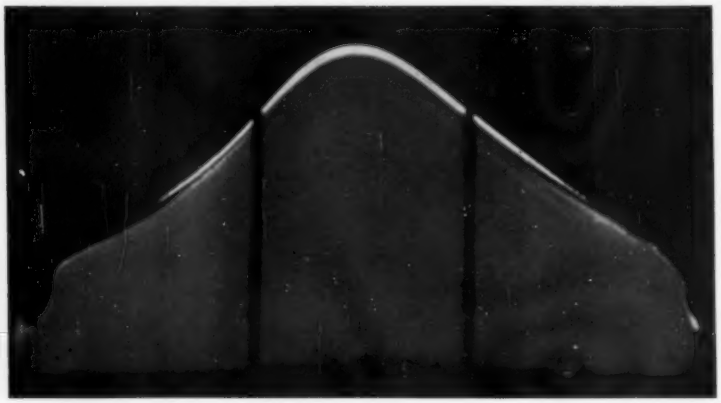


*Fig. 6 – Autoradiograph Showing Solidification Boundary in Continuously Cast Aluminum Ingot*

trical Industries, Esso and Shell Petroleum companies and some universities.

The Thornton Research Center of the Shell Petroleum Co., in particular, by using radioactive piston rings in internal combustion engines and monitoring the radioactive debris in the lubricating oil, have discovered many previously unknown facts about wear. When wear is measured quantitatively under varying controlled conditions, special lubricating oils have been formulated to combat wear and prolong engine life.

**Radioactivation Analysis**

The basis of this method of analysis is that the element to be determined is made radioactive by irradiation in a reactor and this radioactivity is then used as a measure of the mass of the element originally present. Because of the great sensitivity of the instruments used for measuring radioactivity, and because of the specific characteristics of individual radioisotopes, such as half-life and type and energy of the emitted radiation, the new method is very attractive.

So far most of this activation has been in the Harwell pile BEPO, with a flux of more than $10^{12}$ neutrons per sq. cm. per sec. Industrial and university laboratories in Great Britain are making increasing use of the method for their own analytical problems, sending samples to Harwell for irradiation, and analyzing them either in their own radiochemical laboratories or at Harwell.

A. A. Smales has recently shown that nickel, copper and cobalt can be determined in a wide range of rocks and minerals down to $10^{-7}$, $10^{-10}$, and $10^{-8}$ g. levels where these elements are present to only a few ppm. in microgram samples. The large difference of half lives (2.5 hr., 12.8 hr., 5.3 years) makes it possible to deal adequately with the successive radiochemical separations. This work showed that, for example, there has been no significant contribution of meteoric material to the nickel content of marine sediments. Again submicrogram amounts of thorium and uranium have been determined by E. N. Jenkins and Smales by irradiating samples and estimating the 22-min. beta active thorium-233, and the fission product barium-140.

Radioactivation is particularly suitable for determining minute quantities of trace impurities in pure metals. Calcium, which is almost impossible to measure by conventional techniques at the ppm. level, has been determined by Smales. Recently sodium has been estimated in pure lithium metal down to 0.02 ppm.

In the field of semi-conductors where purity requirements are unique, the arsenic content and the segregation constant of nickel in germanium, and the arsenic and copper content of silicon (to 1 part in $10^{10}$) have been determined by Smales.

He has also determined oxygen by utilizing the (n, $\alpha$, T) reaction on oxygen to give fluorine-18. Sensitivity in available pile fluxes is about 0.1%.

A combination of radioactivation and autoradiography has been used by J. L. Putman to find the solidification boundary in continuously cast aluminum in the following manner: Inactive gold was added to the molten aluminum as it flowed into the mold during casting. This billet-top containing 7 ppm. gold, was sectioned, polished and irradiated. The shape of the solidification boundary is shown in Fig. 6, a photograph taken 10 days after irradiation when the short-lived impurities had decayed. A series of striations caused by the repeated arrival of gold-rich material at the boundary can be seen. Later work by D. M. Lewis of British Aluminium Co. using radioactive gold directly, enabled the gold tracer content to be reduced to 1 ppm., and improved the clarity of the radiograph by reducing background fogging.

# Glass Baths for Heating Steel Extrusion Billets

*By OSVALDO BALESTRA**

**Considerable savings in fuel and maintenance cost have been realized by using a gas-fired molten glass bath instead of a salt bath for preheating steel extrusion billets. (F 21, F 24)**

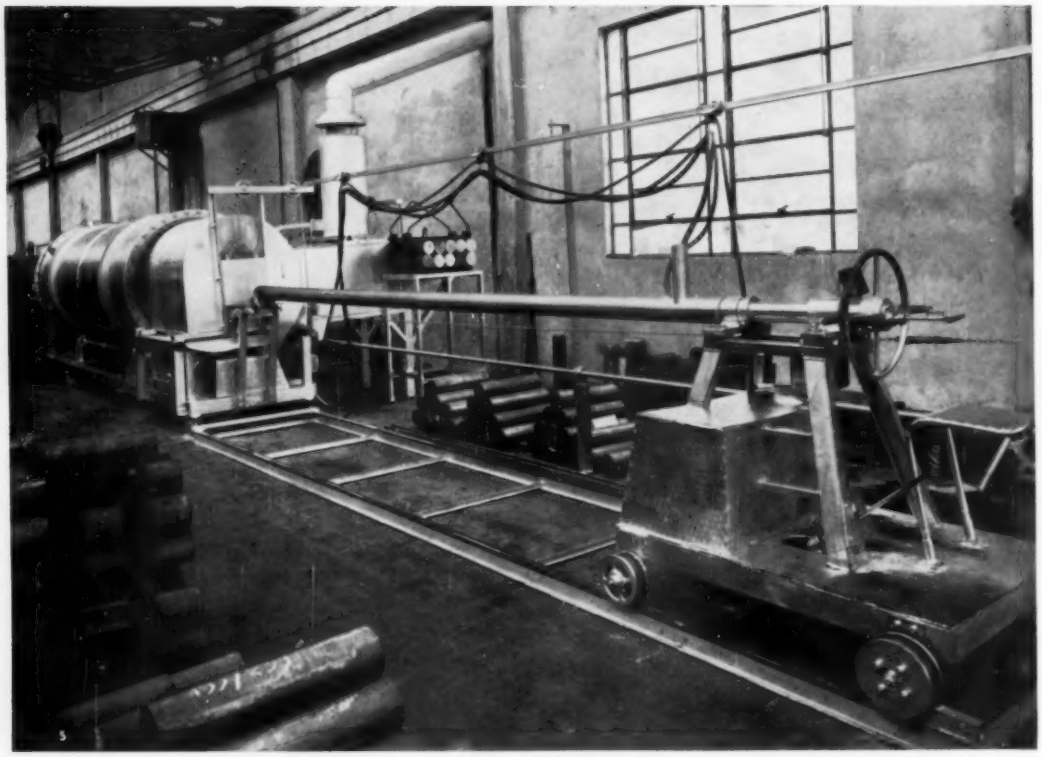
IN THE ARTICLE "Extruding Metal With Glass Lubricants," by J. Delcroix which appeared in the January 1956 issue of *Metal Progress*, there was a brief mention of the billet heating process which was then under development at the Fiav Mazzacchera extrusion plant. We have now been using this process continuously in production for more than a year and have made considerable savings in our operating costs.

When the plant started operations as a licensee of the Ugine-Séjournet extrusion process, the extrusion billets were preheated to about 1650° F. in a gas furnace and then brought up to the extrusion temperature of about 2280° F. in an electric salt bath furnace. This salt bath soon proved to be too costly because it required so much maintenance, particularly as far as electrodes were concerned. There were also a number of problems connected with material handling and billet discharging. In addition, power consumption was very high so that the heating costs were far exceeding the selling price of the products.

Because of the many inconveniences and difficulties experienced with the salt bath, a new gas-fired rotary-type furnace was designed and developed by the author. In this furnace, billets can be heated out of air contact so that no surface oxides are formed, and higher temperature may be reached than in conventional heating furnaces without overheating and burning of the material being treated.

The furnace is essentially a sheet steel shell lined internally with silica-alumina refractory bricks and equipped with a charging hole at one end and a discharging hole at the other. The discharging side is equipped with a natural gas burner (using gas having a heating value of 930 Btu. per cu.ft. which costs 0.34 lira per cu.ft.) mounted axially with respect to the furnace shell. To start the operation, some common glass scraps are loaded into the slowly rotating furnace.

*Technical Director, Fiav Mazzacchera Co., Milan, Italy.



*Charging End of New Glass Bath Furnace*

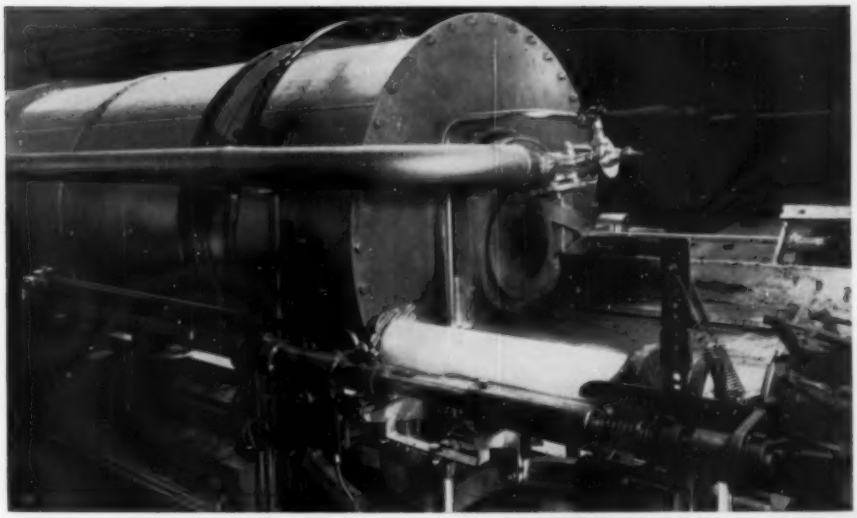
These scraps melt and flow down to cover the furnace bottom, forming a layer about 4 in. deep. The billets are preheated to about 1110° F. by the combustion waste gases being exhausted from the discharging end of the furnace and then are charged in the furnace with their horizontal axis parallel to the rotation axis of the furnace. Because of the furnace rotation, billets roll down into the melted glass, which thoroughly descales the billet surfaces by converting all oxides into iron silicate, and then forms a protecting layer which, being gas-proof, prevents any further oxidation of the steel.

In this type of furnace, heat is transferred with high efficiency even if the glass conductivity is very low. Heating is not by radiation and convection as in the usual heating furnace, but by conduction from the melted glass which, in turn, absorbs heat mainly by conduction from the furnace walls during rotation of the furnace.

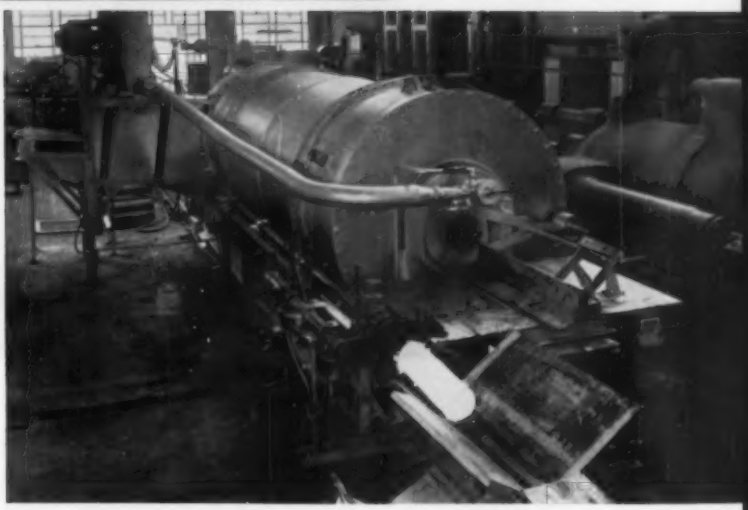
The charging of billets and their movement within the furnace are controlled automatically by a water cooled steel pusher. Billets are discharged through a cylindrical sector step placed near the discharge door. The rotary glass furnace also has a special automatic device for billet conditioning before extrusion. When they leave the furnace, the billets are thoroughly coated with a melted glass layer a few tenths of an inch thick which has to be removed. It is removed automatically by means of a simple mechanical device which first scrapes off the top and bottom of the billet and then removes most of the adhering glass from the surfaces by means of a set of suitably spaced scraping knives. After this treatment, the billet is ready for charging into the extruding chamber of the press.

The glass bath heating furnace can be mechanized and automated for most of its operations. A new furnace recently installed in the extrusion department has been so mechanized. It replaces the original unit which, though experimental, had been operated economically for months in routine production.

The new furnace has an inside diameter of 23 in. and is 12 ft. 8 in. long. It is equipped with a natural gas burner, rated at a maximum of 1765 cu.ft. per hr. The waste gas exit end is equipped with a billet preheating chamber which is 5 ft. 8 in. long. This furnace can be operated

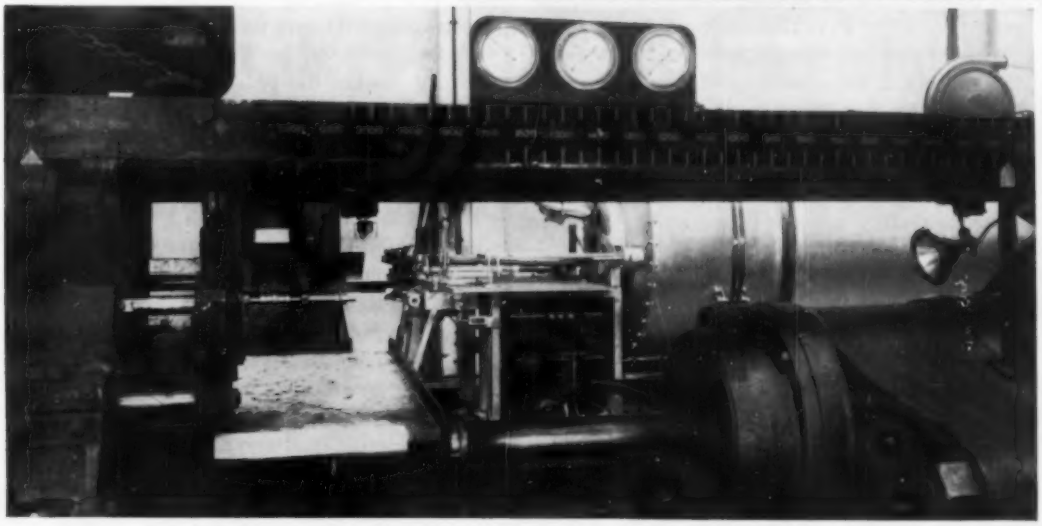


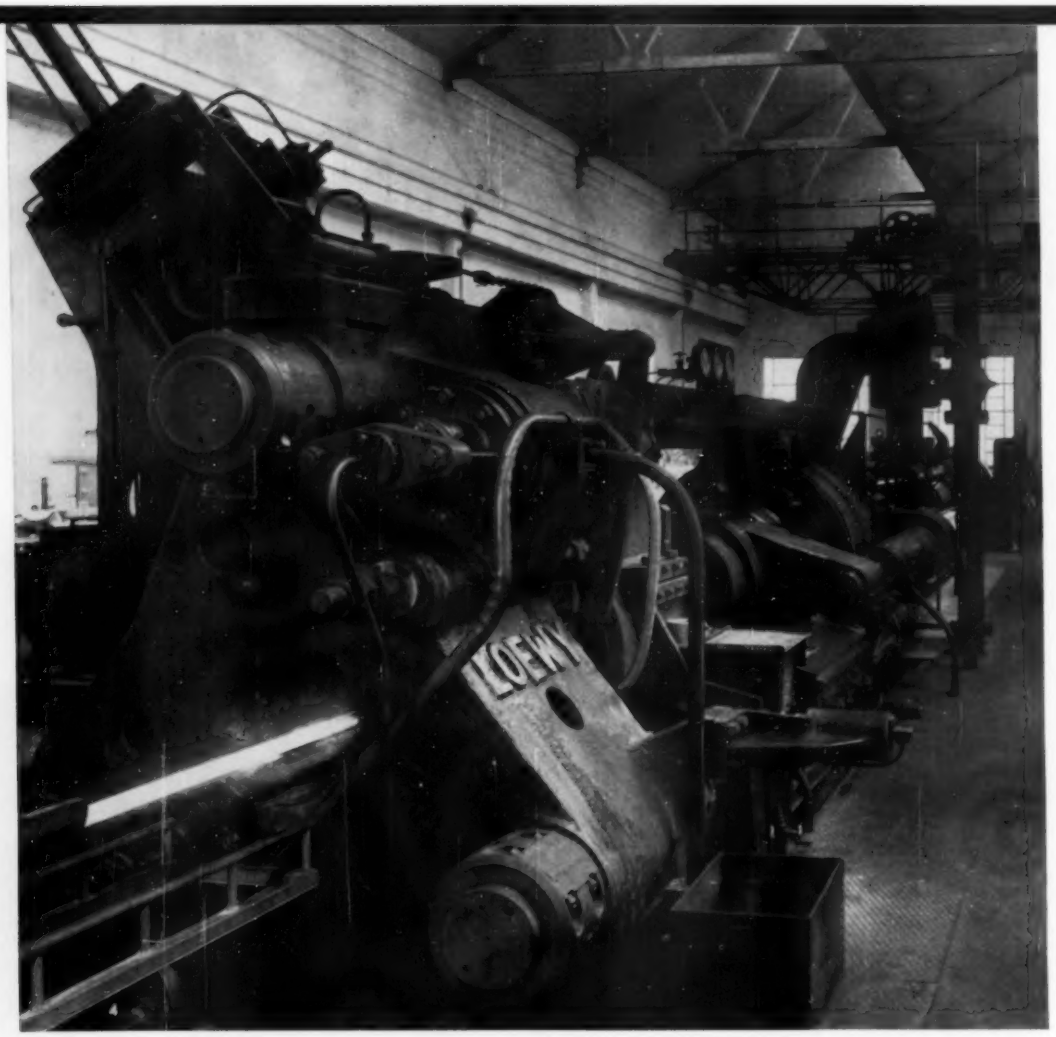
*Automatic Scraping of the Ends of a Heated 6-In. Billet*



*Scraper Used to Remove Excess Glass Adhering to Billet Surface*

*Charging the Billet Into the Extrusion Press*






*Discharge End of 1150-Ton Extrusion Press*

continuously with solid or hollow billets, ranging from 4 to 7 3/16 in. in diameter. The average gas consumption for heating from room temperature up to 2370° F. is 1765 cu.ft. per ton of billet.

One of the most outstanding advantages of this furnace is the possibility of using far higher temperatures than those economically obtainable in salt bath furnaces. For example, in the expensive barium chloride furnaces billets may be heated to 2190 to 2280° F., while the glass bath furnace readily attains temperatures between 2370 and 2460° F.

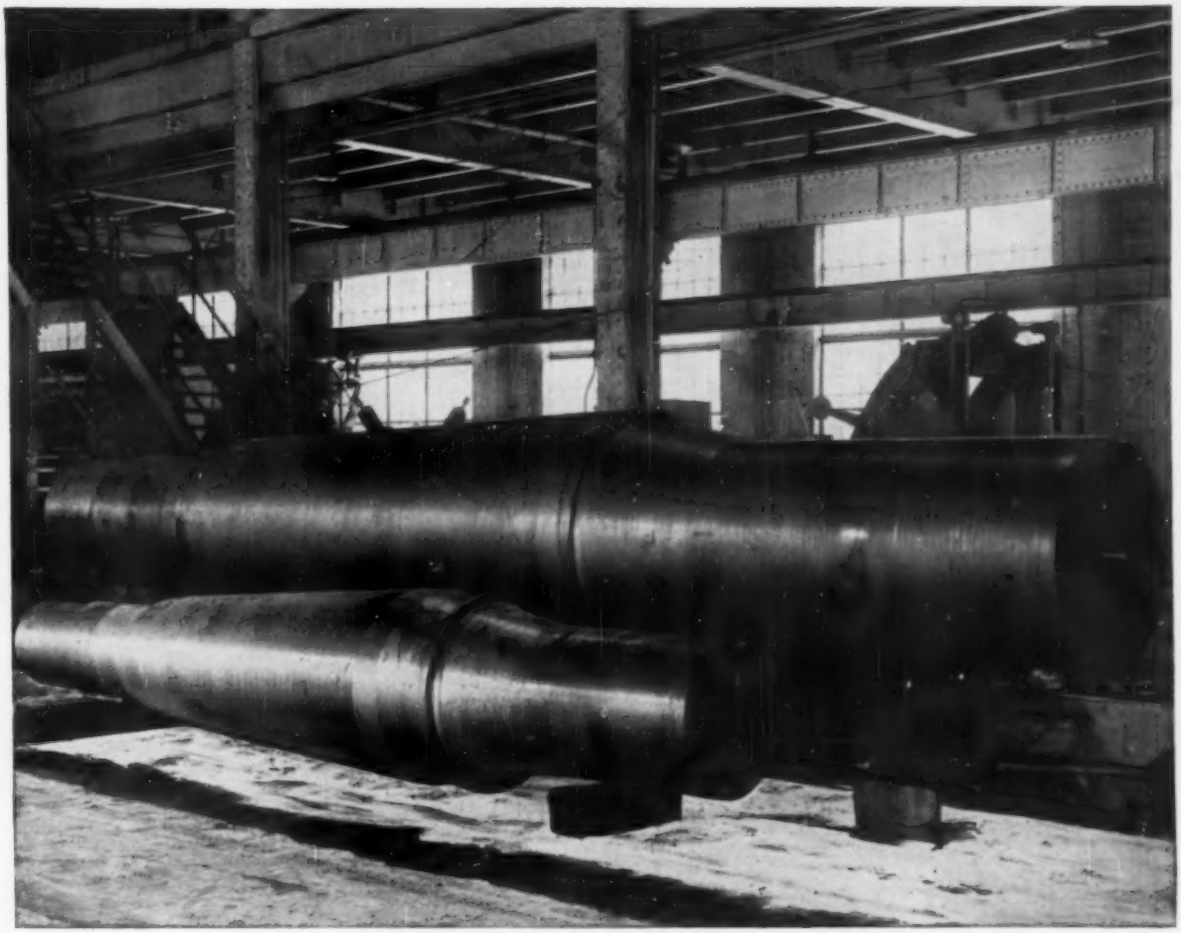
The melted glass not only protects billets during the transfer from furnace to press, but also prevents burning or overheating. The higher temperatures improve ease of extrusion and reduce wear of dies and other press tools.

As far as manpower is concerned, one man at each furnace end is now required for a furnace producing at the rate of 1 ton per hr. and complete automation is possible.

Experience gained through months of operation with the glass bath furnace has shown that the cost of heating billets for extrusion (labor costs excluded) may now be figured at 1.52 lira per kg. compared to the average of 29.36 lira per kg. during the period in which an electric salt bath furnace had been used for billet heating.

The main advantages of the new furnace can be summarized as follows:

1. Low installation cost.
2. Low operating cost.
3. Longer die and tool life.
4. Simplified material handling.
5. Higher speed of heating.
6. Uniformity of heating.
7. No oxidation of material.
8. No decarburization of material.
9. Hot descaling of pre-existing oxides.
10. Heating to above 2370° F. without danger of burning.
11. Use of extrusion presses of lower rating.



*Forged from 3½% Nickel Steel — These gyratory crusher shafts weigh 102,000 and 34,000 lbs. and are 25 and 17 feet long respectively. They were produced by Bethlehem Steel Company, Steelton, Pa.

## *In large forgings like this...**

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Usually husky parts like this cannot be quenched without special facilities.

How then do you get the superior mechanical properties often required in heavy-sectioned parts?

By selecting a nickel alloy steel that doesn't need a liquid quench to develop strength and toughness.

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The tests of time and laws of metallurgy have proved nickel to be most valuable in developing high mechanical properties in heavy forgings. Nickel, often acting with other alloying elements, increases the hardening response of steel parts too large to liquid quench. The resulting microstructure formed gives added strength and improved toughness.

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# Classification of Titanium Alloys

By T. W. Lippert, Manager of Sales and Technical Service, Titanium Metals Corp. of America

The systems currently used to identify titanium alloys are either based on nominal tensile strength or yield strength values ("Ti-75 A" indicating a nominal tensile strength of 75,000 psi.), or actual naming of the major elements ("Ti-6Al-4V" being an alloy containing 6% aluminum and 4% vanadium). These designations are clumsy or inadequate since the alloy may differ in tensile or yield strength depending upon whether it is made into bar or sheet, whether annealed or partially cold worked, or whether further worked or heat treated in the customer's plant. Any attempt to identify alloys by listing chemical composition is unwieldy and may become intolerable as compositions become more complex in the future.

A new titanium nomenclature system which has been adopted by Titanium Metals Corp. of America is so constructed as to impart definite intelligence as to the composition, nature and probable behavior of a particular alloy of titanium. It also effectively differentiates between almost identical alloys. Five digits are used to avoid confusion with S.A.E., A.I.S.I. and A.S.T.M. code numbers for other metals. In addition, a prefix "T" is used to indicate that the alloy is titanium-base.

This coding system ignores hydrogen which has extensive beta-phase interstitial solubility. Hydrogen limits are usually set by specification, with most alloys now limited to a maximum of 0.015%. The coding also ignores carbon which has significant alpha-phase interstitial solubility. It is assumed that this element is limited to less than 0.10%. It might be noted also that no provision is made for indicating the nature of the alpha-soluble elements, only the *total* percentage. Aluminum is the only element which as yet has shown useful alpha-phase solubility, although tin is gaining favor in supplementary quantities. Other elements, such as germanium, lead and silicon, which may show some useful alpha-phase solubility, do not appear to have any immediate promise.

The various major categories of titanium metal thus may be grouped as shown below. If no suffix is used, the alloy is in the fully annealed condition. The suffix S indicates that it has been solution heat treated; the suffix A means that it has been solution heat treated and artificially aged.

| Present Designation | Chemical Composition | | | | | | | Proposed Classification |
|---|---|---|---|---|---|---|---|---|
| | Fe | Cr | Mo | V | Al | O | N | |
| Ti-55A | — | — | — | — | — | 0.18 | 0.012 | T00020 |
| Ti-65A | — | — | — | — | — | 0.23 | 0.012 | T00025 |
| Ti-75A | — | — | — | — | — | 0.33 | 0.012 | T00035 |
| Ti-100A | — | — | — | — | — | 0.38 | 0.012 | T00040 |
| Ti-140A | 2 | 2 | 2 | — | — | 0.33 | 0.012 | T96035 |
| Ti-155A | 1.5 | 1.5 | 1.2 | — | 5 | 0.18 | 0.012 | T94520 |
| Ti-6Al-4V | — | — | — | 4 | 6 | 0.18 | 0.012 | T34620 |

| | |
|---|---|
| Commercially pure grades | T 000XX |
| All alpha titanium alloys | T 00XXX |
| Alpha-beta titanium alloys | |
| Reserved | T 1XXXX |
| Silicon | T 2XXXX |
| Vanadium | T 3XXXX |
| Molybdenum | T 4XXXX |
| Reserved | T 5XXXX |
| Manganese | T 6XXXX |
| Chromium | T 7XXXX |
| Reserved | T 8XXXX |
| Iron | T 9XXXX |

### First Digit

The first digit indicates the major element contributing to beta stabilization. Elements that fall within this category are silicon, vanadium, molybdenum, manganese, chromium and iron. These elements have been assigned a digit the order of magnitude of which is roughly proportional to the element's effectiveness: Si is 2, V is 3, Mo is 4, Mn is 6, Cr is 7 and Fe is 9. Digits 1, 5 and 8 are reserved for elements which may prove effective in the future. In coding, the highest value digit that applies is used. For example, an alloy containing Fe and Cr would have 9 representing the iron content rather than 7 denoting Cr. For an alloy containing Mo, Cr and V, the digit would be 7 for Cr rather than the 3 for V or the 4 for Mo.

### Second Digit

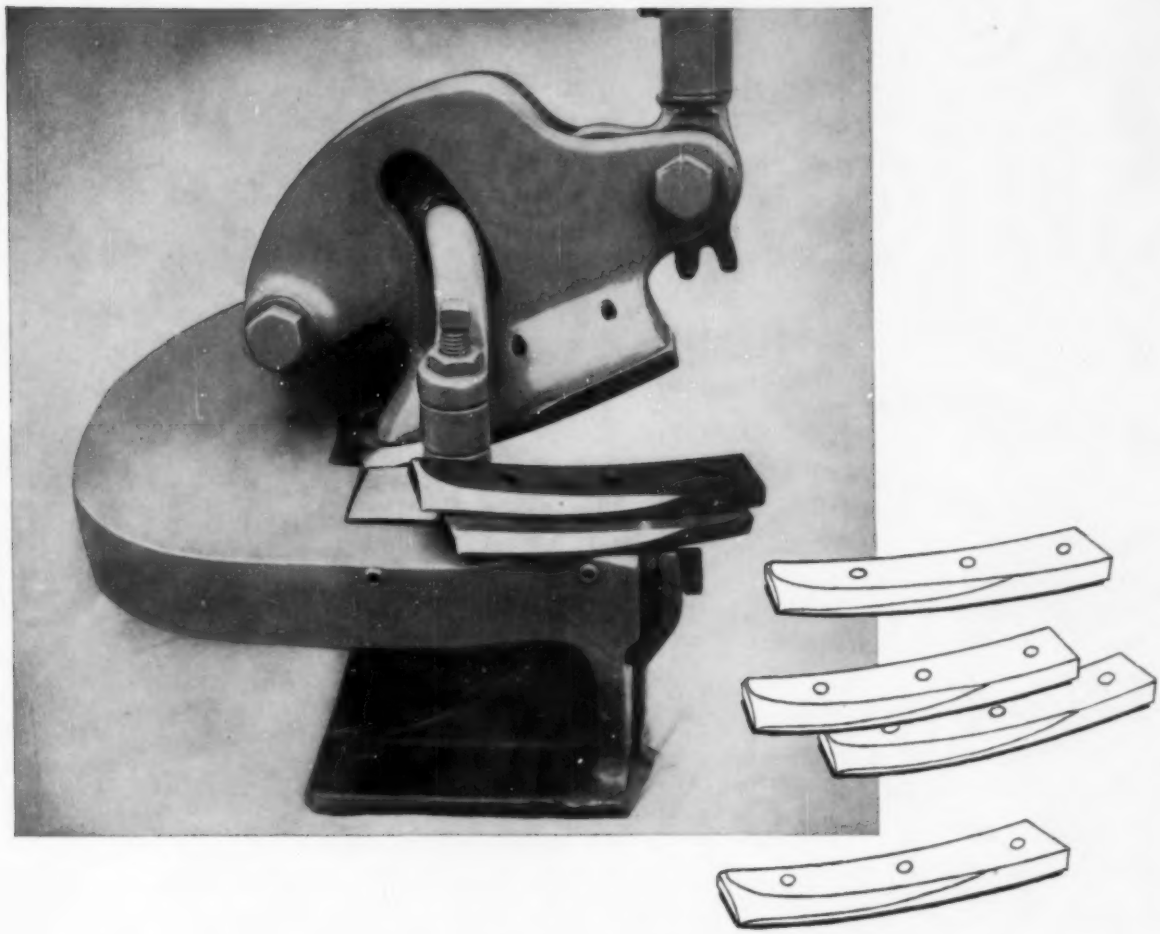
This digit equals the *total* percentage of all elements contributing to beta stabilization. Thus, for a 2% Fe, 3% Cr alloy, this digit would be 5; while for an alloy containing 1.5% Fe, 1.5% Cr and 3% Mo, this digit would be 6.

### Third Digit

The third digit equals the *total* percentage of all elements, other than oxygen and nitrogen, contributing primarily to strengthening other than by beta stabilization, such as aluminum, tin and zirconium. For example, an alloy containing 6% Al would be designated 6. For an alloy with 3% Al and 1.5% Sn, this digit would be 5.

### Fourth and Fifth Digits

The fourth and fifth digits indicate oxygen percentage plus twice the nitrogen content, expressed in hundredths and rounded off to the nearest 0.05 increment. Thus, for an alloy containing 0.08% oxygen and 0.02% nitrogen, these two digits are shown as 10 since $0.08+2\times0.2=0.12$, which rounds off to 0.10 (or 10 in the code.)



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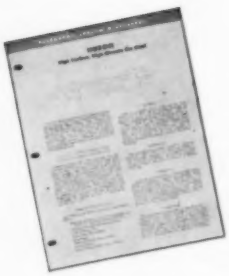

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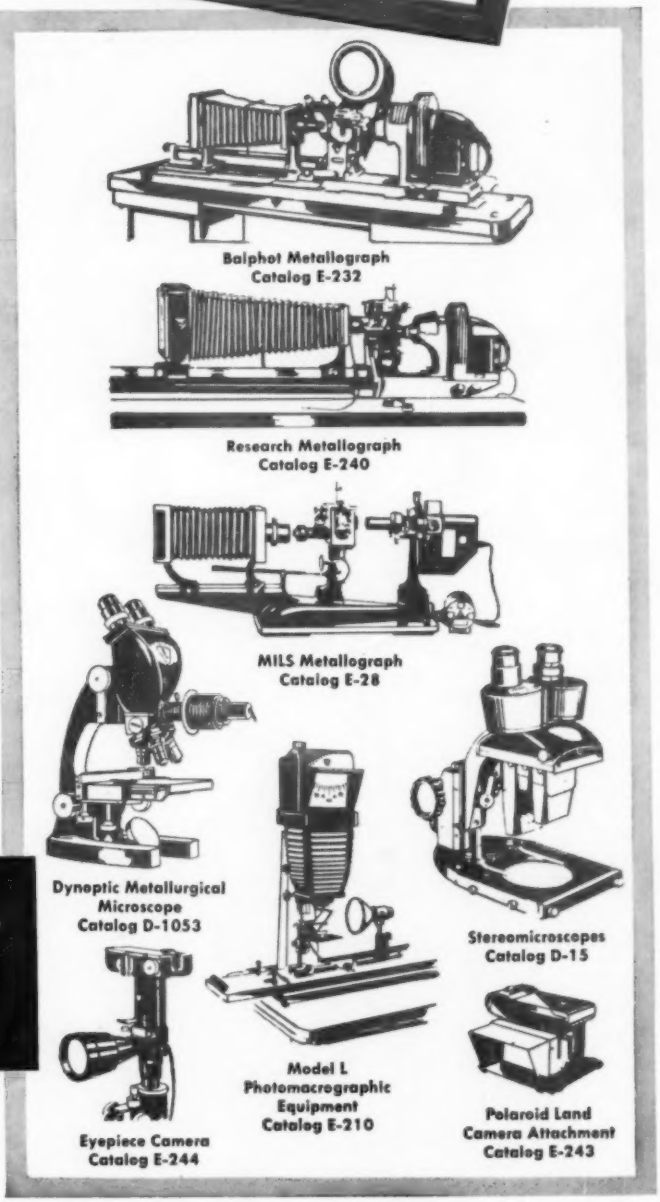


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# Advances in European Drop Forging

*By TOM BISHOP**

**Industry-sponsored investigations of drop forging practice have resulted in increased die life and more efficient equipment. (F 22)**

WHILE THE DROP FORGING INDUSTRY is not one which readily lends itself to great improvement by research (it is one of the oldest techniques of shaping metal), nevertheless, considerable research and development are being applied to production methods in Britain and Europe. The drop forging research section of the Hannover Technische Hochschule has one laboratory devoted solely to drop and press forging which is equipped to cover almost all aspects.

In 1947 the German Association of Drop Forgers sought cooperation with a technological university, and in 1950 the "Drop Forging Research Dept." was founded as a section of the Institute for Machine Tools Dept. at the University of Hannover. The scope of work in this department includes study of the efficiency and accuracy of machines and dies, effect of wear of dies and of scale on the accuracy of the forgings, the proper methods of forming drop forgings and the investigation of all subjects which are included in the diemakers' departments, such as economy in diemaking with special reference to improvement of tools for diemaking. A practical approach has been pursued as distinct from an academic or purely scientific treatment of the subject in order to assure cooperation from industry.

One example of research work in progress is a study of the wear of forging dies. The surface of a die which has been in service may show three different kinds of wear, as shown in Fig. 1. The first occurs in zones subjected to compressive strains where there is no sliding of material along the die surface. The second is found in zones subjected to both compressive strain and shearing strains caused by friction between die and material, and the third in zones of sliding friction where the strain is primarily shear caused by sliding of the material along the die surface.

The extension of these three zones depends very much on the deformation speed. The difference in wear resulting from forging on a drop hammer and on a friction screw press is shown in Fig. 2. The wear of dies on the press was about three times as great as on the hammer for the same number of identical forgings.

Wear by abrasion alters the dimensions of the impressions in relation to the working time of the dies as shown in Fig. 3. Initially, the dimensional change is due to plastic deformation of the die. Next is a steady rate of growth due to die wear by abrasion. The final stage is a rapid dimensional alteration of the impression which either increases or decreases as a result of fatigue or surface cracks combined with new plastic deformation. In order to measure the wear caused by abrasion, the gradient of the curve is used. The rate of wear depends on many individual influences, including the kind of forging machine, the die material and its heat treatment, forging material, heating method and scaling, forging temperature, surface condition of the impression, die lubrication and type of preforming.

Experiments with hand-polished, wet-honed and shot-blasted impressions have indicated that, regardless of the surface treatment, the die wear is virtually the same if the initial surface roughness is less than 10$\mu$. Therefore, it is not worth while to smooth the surface too much. Wet-honing the surface offers some economic advantages because this process saves much working time and the condition of the surface obtained by this method does not influence the die life noticeably.

Die life can be doubled or tripled by hard chromium plating. A wear resistant chromium

*Editor, *Metal Treatment and Drop Forging*, London, England.

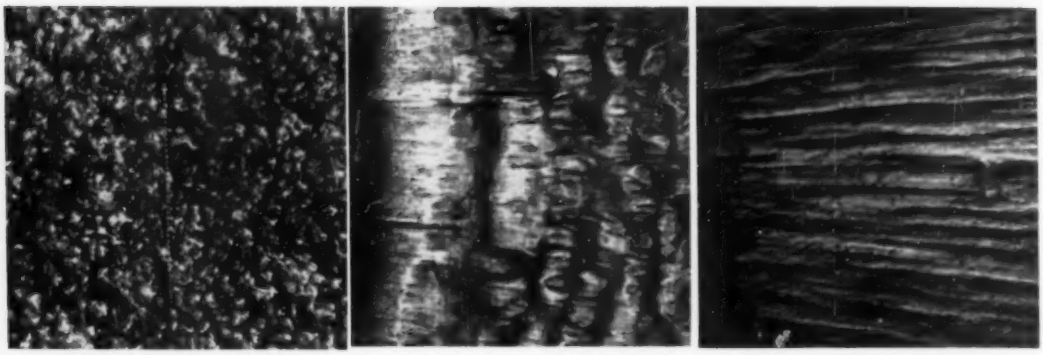


*Fig. 1 – Kinds of Wear in Drop Forging Dies. Wear due to pressure only shown at the left, wear due to a combination of pressure and friction in center, and wear from friction only shown at right. 10 ×*

plate can be obtained by slowly depositing the plate at a current density of 40 amp. per sq.dm. A plate thickness of 20 to 40$\mu$ was found to be best if the die life is controlled by wear and not by other reasons, such as cracks or sharp corners. An additional advantage of hard chromium plating is that the forgings do not stick to the impressions as much as with unplated dies. The result is an increased output; in one instance, an increase of 10% was achieved.

The French are also improving die life by hard chromium plating the impressions and gutter with a 40-$\mu$ coating of chromium. It is said to be particularly useful in shallow impressions and where the material flows in a horizontal direction. Die life has been trebled by this method.

For trimming dies, the French use carbon steel and apply an alloy to the cutting edges by electric welding. An alloy which has been used successfully for this application is OKH 6, with a composition of 0.84 C, 1.14 Mn, 3.8 Cr, 5.5 Mo, 1.9 W and 1.7 V. The die can be re-used when worn by rewelding, truing and hardening.

Forging dies are often made from an air hardening steel with a composition of 0.35 C, 0.35 Mn, 3.5 Ni, 1.5 Cr and 0.30 Mo. Dies are air cooled from 900° C. (1650° F.) and tempered for 2 hr. at 200 to 250° C. (390 to 480° F.). Such die blocks are satisfactory but must be annealed before resinking impressions and then rehardened. This increases costs and may cause distortion. Drop forgers who prefer to machine dies in the tempered condition use an alloy whose composition is approximately 0.55 C, 0.59 Mn, 1.3 Ni, 1.3 Cr, 0.4 Mo and 0.2 V. Its hardness is about Brinell 415.

In England, there is a trend in the design of gravity drop hammers toward the use of shorter and faster strokes, which should be welcomed by the drop forger. Although it requires the use of a heavier tup to compensate for the loss in stroke, it does lead to higher production and improved die life. The reduced impact velocity also lessens the risk of damage to the hammer since the stress imposed is proportional to the square of the speed. The reduction in stroke results in a shorter and sturdier machine. These advantages are particularly beneficial when mul-

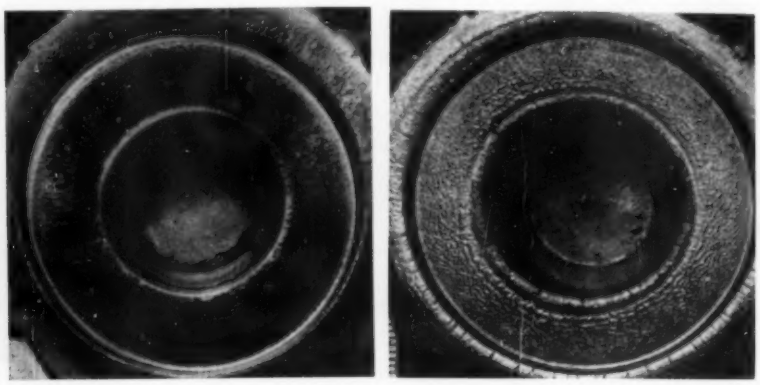


*Fig. 2 – Difference in Die Wear on Drop Hammer (Left) and Friction Screw Press (Right). The wear of the latter is three times as severe as the former*

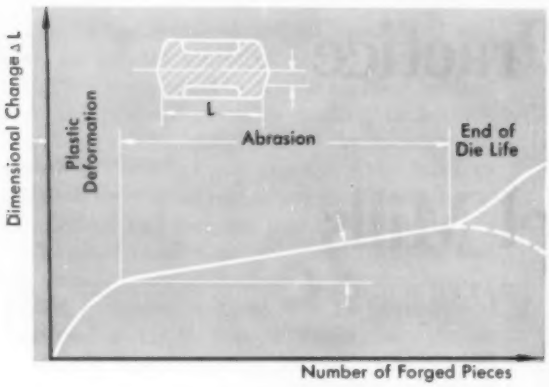



*Fig. 3 – Die Wear as Measured by Dimensional Change of the Forgings Produced*

tiple-impression dies involving off-center work are employed. It might well be noted here that the extent to which work is done off-center should be strictly limited, and a good general rule is that the center line of the off-center impressions should fall within the width of the standard die dovetail.

The ratio of anvil-block weight to tup weight also has an important bearing on the efficiency of the drop hammer, and it has been found that the optimum ratio of anvil-block weight to tup weight consistent with economy is 20 to 1. With lower ratios the efficiency decreases considerably and with higher ratios the increase in efficiency is negligible.

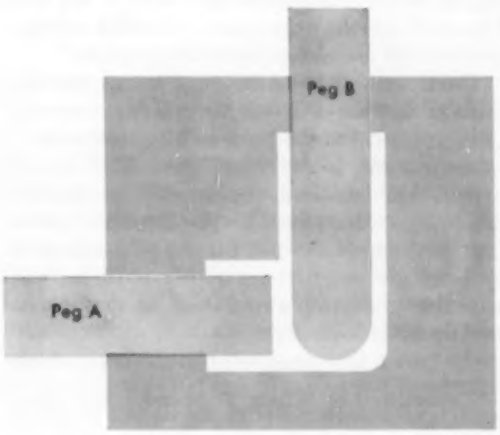
The technique of producing cored forgings, especially in brass, was developed in England and on the Continent, and has been introduced in the U.S.A. and Canada only recently. When hollow or tubular components were required in forged brass, it was the practice to forge a solid blank and then machine to the final shape. A much more satisfactory and logical procedure is to arrange that the forging be produced with the hollow as nearly completely formed as possible. This can be done by equipping a closed die with the necessary core rods or pegs which are mechanically positioned immediately before pressure is exerted on the hot metal. With a specially constructed crank press, it is easy to arrange for the various pegs to be brought into place rapidly and accurately. The plastic metal is deformed to fill the die cavity, and since it is subjected to constraint and therefore able to flow without fracture, it is extruded round the cores to form the hollows.

The two parts of the die are brought together by the horizontal action of the press, and a hot cylindrical billet is dropped in place. Operation of the press first brings peg A into the position shown in Fig. 4 and locks it in place, then pressure is applied to the billet through peg B. The forging is formed partly by the piercing action of peg B but mainly by extrusion of the metal until the whole of the available space in the die cavity has been filled. The sequence of operations continues as the crank completes its cycle; the pegs are automatically retracted, the die halves are opened and the finished forging is ejected. The pegs must not be allowed to contact each other, hence the hollows in the forging are always blind-ended. In the final drilling operation, however, very little metal has to be removed.

Some flash must be trimmed off. Since the pegs must be a sliding fit in the outer parts of the die, small tongues of metal are formed at these points by extrusion into the necessary clearance space. The remainder of the flash occurs at the junction of the die halves and assumes a shape which depends on the local variations in pressure within the die cavity and on local variations in temperature of the metal due to chilling. The loss of metal in the flash corresponds to the amount by which the billet exceeds the required weight.

As a result of a very large amount of development work on the design of presses and dies, this process has become very efficient. It is claimed that the cored forging process is the quickest and most satisfactory method employed for the production of plumbers' fittings, taps, valves and similar brass hardware.

*Fig. 4 – Arrangement of Pegs Used for Cored Forgings*



# Heat Treating Practice in Russian Steel Mills

*By LEE WILSON**

**First-hand observations of Russian production equipment and techniques obtained during a visit to two steel mills during 1956. (F general, D general, J 23)**

MAGNITOGORSK is a city of some 500,000 people located on the Ural River which separates the Asian and European parts of Russia. It is about eight hours flying time from Moscow. The steel mill is on the Asian side of the river and the workmen's homes are on the European side.

This plant has eight blast furnaces; four of them are 26 ft. in diameter with a capacity of 48,000 cu. ft. and the other four have a capacity of 41,500 cu. ft. For ore an 86% agglomerate is used which comes from a magnetite hill just above the mill. The larger ones are said to produce 2200 tons of pig iron per day.

The blast is preheated to between 850 and 900° C. (1560 and 1650° F.) and is blown in at the bottom at a pressure of 2.5 atm., and the top pressure is maintained at 0.9 atm. The moisture content of the blast is maintained at 25 g. per cu.m. by additions of steam. One heat of pig iron whose analysis I saw contained 0.84% silicon, 0.18% manganese and 0.041% sulphur. I was told that the manganese content was seldom above 0.20% and was usually about 0.15%.

There are 28 openhearths, three 380-ton, thirteen 250-ton and twelve 200-ton furnaces. Oxygen is used in the burners with a mixture of coke-oven and blast-furnace gas. The use of oxygen has increased the average production rate by approximately 25%. The Russians believe that the best way to put oxygen in the steel is by lancing through the roof but have not yet been able to develop a roof structure that would hold up in such service.

They use a low-pressure oxygen system which compresses it to 6 atm. in one stage, known as a single-stage low-pressure system. It produces oxygen of about 94 or 95% purity at a cost about 15% below that of the high-pressure methods.

It was interesting to note in passing that none of the openhearth chimneys were smoking although I'm sure they were all operating full-tilt. From what I have been able to observe, the smoke control at this plant is better than normal – even better than it is in the United States.

In the sheet mill, there is a German three-stand cold reversing mill for three-ton hot bands. The temper mill was a two-stand German mill. Both of these were 1 m. (40 in.) wide. All of the auxiliary gear on this equipment was built by CKM-3, a machine builder in Kharkov, although we did see some German Demag shears and shearing lines. The mill seemed to be operating at a good rate of speed and without any fuss or fume; however, the entire appearance of the floor and area around the mills was untidy and the operation didn't look very up-to-date.

In the annealing department, they have 16 gas furnaces, 48 × 220 in. in length. They anneal everything in flats, usually three stacks to a furnace. They also have three electrically heated vacuum furnaces which have flat bases for the treatment of electric sheet such as silicon iron. These furnaces operate under a vacuum of about 25 in. of water. Vacuum pumps are in the basement and the furnaces are sealed at the bottom with a rubber seal – like our sand seal, except that underneath the soft gum rubber is a water-cooled section which the rubber rests on. The upper portion of the furnace shell is also water-cooled so there is no heat on the seal itself.

*Chairman, Lee Wilson Engineering Co., Inc., Cleveland.

The 16 gas furnaces are all direct-fired and have an exhaust outlet on end at the bottom. Hot gases are ejected by a cold air blast leading into an open-end chamber leading to a stack outside of the building. All of the furnaces are vented in the same way and all of the furnaces are fired against carborundum muffles similar to the method that Heurtey uses in France.

The steel coming out of these furnaces was not clean. It was either heavily blued or heavily sooted, and none of it looked to be in very good condition as far as United States practices are concerned; however, they seemed quite pleased with it.

The atmosphere machines are of a DX type in which they burn a mixture of coke-oven and blast-furnace gas with a heat content of 250 Btu. per cu. ft. They remove the sulphur with mono-ethylamine first. The capacity of three DX machines is 150 cu.m. per hr. (5300 cu. ft.) which didn't seem to me to be sufficient for 16 large furnaces. Perhaps a check of the capacity would give some indication of where their trouble lies as far as such bad-looking steel is concerned.

They do not use a refrigerator but do use silica gel as a drying agent. All in all, the practices at this plant seem to be about the same as they were in our country in about 1934 or 1935—about the period when people were beginning to turn from the old hot mill days to the new cold rolling and coil annealing procedures.

We went from the annealing department to the tin-plate department which was under construction. They were installing a new four-stand tandem mill which had been made at their Ural machinery works at Sverdlovsk, about 250 miles due north of Magnitogorsk. We went over this mill as carefully as we could; from all appearances it was a workmanlike job. The control of the mill was entirely hydraulic and the equipment at both ends of the mill seemed to be of the latest design. The mill would operate at 28 m. per sec., or roughly 5600 ft. per min. Its width is 40 in. (1 m.). From all appearances, it looked as though it would be ready to operate in six or eight months but they told me it would be operating in two!

The motors were 2000-hp. units and were built by Electric Mechanic Div. of the Russian Government located at Kharkov. Tho motor room is in an existing building; probably when it is done it will be a nice motor room, but at the present time it is pretty dirty and unkempt. It doesn't have the general appearance of our big air-conditioned motor rooms.

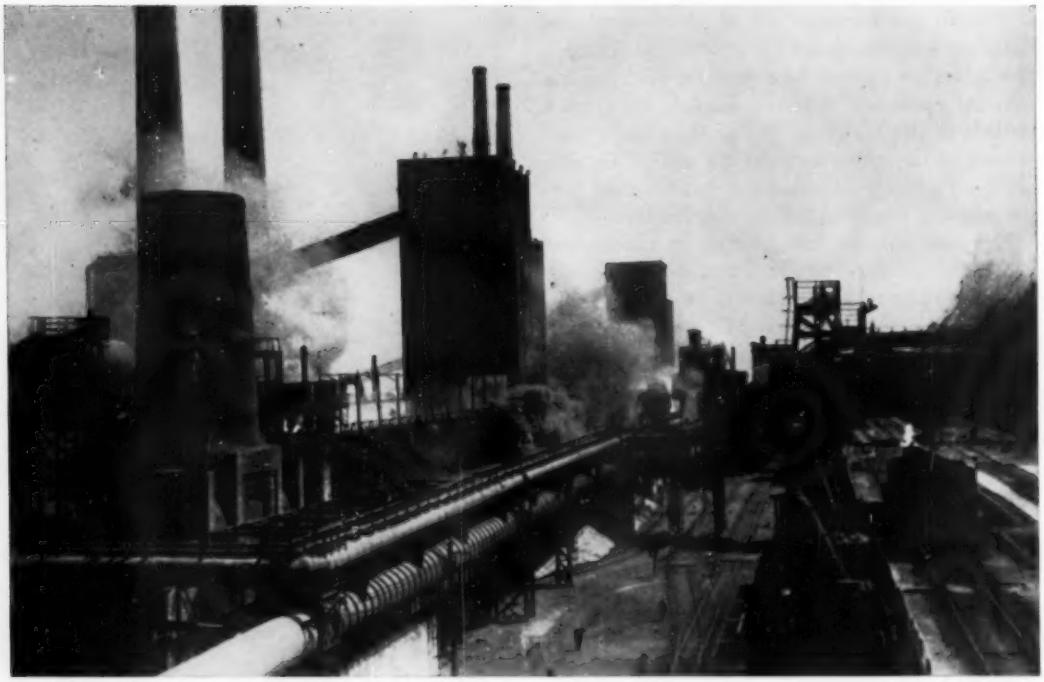
*Route Followed by Mr. Wilson in Russia*

The temper mill is a two-stand four-high mill which is 40 in. wide and runs at 22 m. per sec. (about 4300 ft. per min.) This mill was built by the Ural Machine Co. at Sverdlovsk. (Apparently, Sverdlovsk, on the Ural River east of the Ural Mountains, is the center of the machine tool industry.)

We saw two electrolytic lines being assembled that were made by the CKM-3 Machine Building Section of the Government; however, these were not far enough along to tell very much about them. There were several flying shear lines also made by CKM-3.

The annealing furnaces are to be direct-fired with mixed gas, 14 burners on each side. Header pipes come off a gas main on the furnace which in turn connects to one mammoth supply line, at least 36 in. in diameter, which serves all the furnaces for the entire annealing department.

After inspecting these furnaces quite carefully, we continued our tour and passed a new building under construction, which is to be one of the largest strip mills in the world. We were told that it would produce two million tons of hot and cold rolled strip per year with a maximum width of 2½ m. (100 in.) They have a good start on one of the buildings and expect to have this



*Coke Ovens at Magnitogorsk in the Asian Part of Russia*

plant running within a couple of years. This plant is interested in purchasing designs or furnaces of the single-stack variety. Certainly, if they are going to anneal two million tons a year, they're going to need a lot of single-stack furnaces or a lot of furnaces of some kind.

The plant is not up to American standards of cleanliness and order. Apparently little attention is paid to safety, since many of the men were wearing tennis shoes and many of the women bedroom slippers, even though they were doing construction work. We saw no helmets of any kind nor any safety shoes. There may have been signs about safety but I couldn't read them. I'm sure if we were to ask what was done about safety, the usual answer would be that it was better than the American standards because the worker always must come first in Russia.

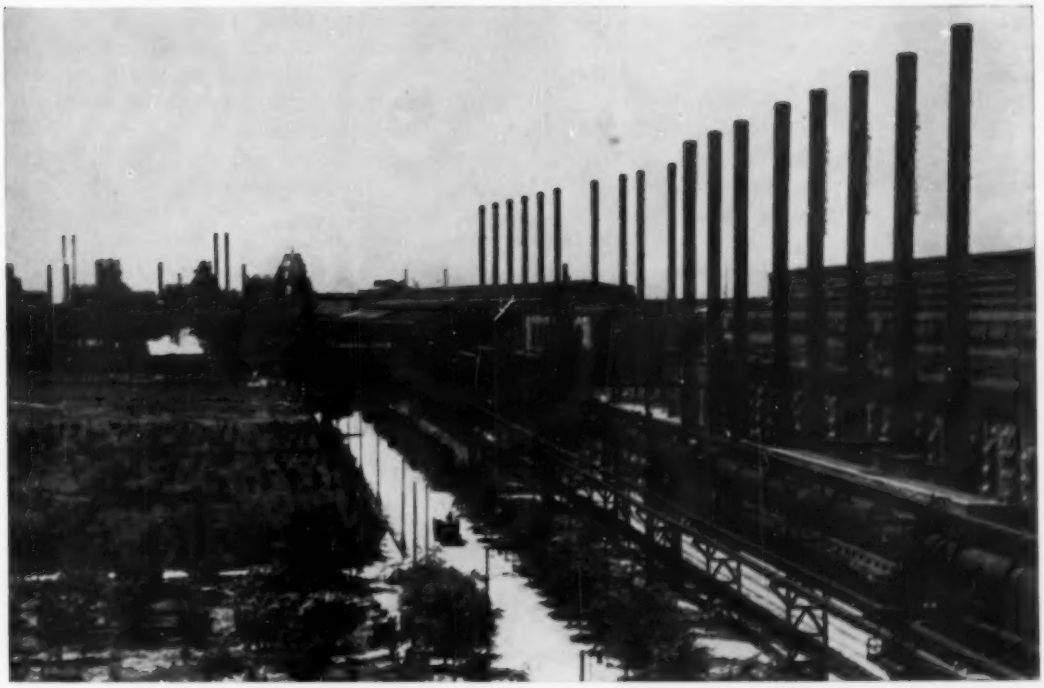
On the other hand, we saw a good many women and men sweeping streets and cleaning leaves, watching gates and doing the kind of jobs that we don't normally find being done by human beings in the United States. Similarly, it was interesting to see the talcum being scrubbed off the silicon sheets by a group of eight women with brushes, instead of by a brush machine, as would be done in the States.

**Zaparozhy Mill**

The other steel mill we visited was at Zaparozhy, Ukraine, on the Dnieper River. It has five blast furnaces, each with a capacity of 1400 cu. m. (50,000 cu. ft.). The blast is preheated to 850° C. (1560° F.) and is blown in at 2 atm. The top pressure is 0.8 atm. In addition to using a high pressure at both top and bottom, they add 25 g. of steam for each cubic meter of air and regulate the steam and air very accurately.

I discussed with them the use of oxygen in blast furnaces, and they said that they had used it in the manufacture of ferro-alloys but had not had any success with it or had not attempted to use it commercially in the manufacture of pig iron. The furnaces, according to their records, have produced 2000 tons per day. They use 800 kg. of coke per metric ton and have a repair life of five to six years. They have an eight-man shift per furnace and produce 2,500,000 tons per year from the five furnaces, which figures back to about 1750 tons per day for four furnaces working continuously, counting one of the five down for temporary causes or complete overhaul.

The furnaces appear to have many automatic features. The loading is all done automatically and is controlled from a central instrument room. A large glass panel shows the location of the skips and the opening and closing of the various



*Openhearth Department of the Zaparozhy Steel Plant in Ukraine*

valves. The entire cycle can be followed in the control room with ease.

One astounding thing is that about 30% of the employees in the entire mill are women. They often dress like men and it was hard for this traveller from a capitalistic nation to tell them apart, particularly when they are covered with dirt or swinging heavy sledge hammers.

The writer didn't see any dust coming from any of the furnaces and the blast-furnace superintendent pointed out that they are the cleanest in Russia. There was no evidence of dust or smoke from the furnaces during our visit. They certainly were better than many of our furnaces in the United States from that standpoint.

There was still evidence of a good deal of American equipment in this plant. The dump cars that handle coke and limestone were all made by Atlas in Cleveland and were still in good repair, even though they had been moved to the other side of the Urals at the time the Germans were in this plant. Two of the blast furnaces had Otis elevators supplied originally by the American firm which built this plant in 1936. The other three had elevators made by the Russians.

After leaving the blast furnaces, we went over to the soaking pits which were of the regenerative type, fired with blast-furnace gas. The ingots that I saw coming out seemed to be well soaked. They had a reasonable amount of scale which was not washed, but were in good shape. This plant has a slabbing mill, two breakdown mills and seven finishing mills in its hot-stand line. As near as I could determine from marks on the housings, all of these mills were built by the Russians, although I was of the opinion that the hot mill may originally have been built by United in this country. The cold mill also appears to be a United mill.

The products coming from the hot mill seemed to be reasonably flat without camber although there was some fire-cracking at the edges.

At the present time, they are grading a sufficient area to put in four additional slab furnaces which they hope will double the production of the hot mill – probably in operation in another eight or nine months. The slab furnaces appear to be of the type built by Rust Engineering Co., although of very early vintage. The slabs coming from the furnaces seemed to be well soaked and to have a very friable sc. e which was not hard to break.

The sheet mill has a United five-stand cold mill and a single reversing stand built by the Russians. The band that comes from the hot mill is in very short lengths and very light coils and is

put through the cold mill without welding. This, of course, results in much lost time and off-gage material. The edges of the hot band were not particularly good; many were fire-checked. The coiling was quite bad and would have to be improved to work well in any modern American equipment.

Everyone was very congenial and helpful. We watched their annealing operations which were all done on flat sheets in electric cover-type furnaces. Atmosphere equipment consisted of two old-style Kemp Deox generators which certainly were not producing a very clean-looking product, and two NX machines using monoethylamine which were designed and made by the Russians.

We didn't see any material from the NX machines but all of the other material in the flat rolled department was thoroughly covered with soot. There were 24 electric furnaces capable of taking a load about 60 in. high, 50 in. wide and 150 in. long.

The outside walls of the furnaces appeared to be of some type of plaster. We asked if this were over a steel case, but got no satisfactory answer — they seemed unable to understand what we were talking about. As far as I could see they were just a pile of brick with buckstays that had been plastered over to make them gas-tight. On the other hand, it's hard to believe that furnaces of this type would not have a tight steel casing. If there was, it was at least 4 or 5 in. inside the outer asbestos or plaster skin.

After leaving the sheet plant, we went over to visit the thin-steel department (we would term it the narrow strip mill). Here they had a number of small mills rolling strip to very thin gages. The quality of the strip seemed to be up to United States average. However, their coil sizes are very small and the results from annealing were not outstanding.

They were using four-stack convector-type furnaces of their own design, with a 7.5-kw. fan similar to the one used by Swindell-Dressler (centrifugal paddle-wheel type). They have a stool made of chromium steel which is set above the stand and acts as sort of a diffuser. It is about 2 ft. in height and shaped so that the inner cover would jam down over it and it would hold the inner cover round at the bottom. This was the one idea in their entire annealing department that seemed to be of value or have some possibilities.

The convector plates were thin sheets of steel with small I-beams about 1 or 1.25 in. high, placed radially. Most of the convector plates I saw were in very bad condition and were not of any great use except as spacers. I showed them how we make ours and they seemed pleased; however, I'm afraid that the type we make would not be useful in their particular operation. The furnaces are about 120 in. high and the coils probably about 40 in. in diameter with an ID of 16 in. or less. The furnaces, according to the annealing foreman, were producing at the rate of 1.5 tons per hr. for the four stacks which is pretty low for this type of furnace. They were electrically heated with elements in the sidewalls. The inner covers were made of 18-9 Cr-Ni steel.

The quality of material, judging from its coloring and oxide, was much better in the narrow strip mill. You could see where the convector bars rested on the steel but other than that the steel was pretty clean. One thing I did notice was that they didn't seem to be concerned about the coil flattening out of shape and many of the coils were lying on the ground on their sides with the center holes completely closed. How they opened these up to put them on spindles I cannot say.

From the annealing department, we went over to the tinning deparment. Five continuous tinning lines were operating at a good rate, making what appeared to me a reasonably good grade of hot dipped tin plate, 14 in. wide. All of it is used in the canning industry and is shipped in coils interleaved with a strip of paper. An electrolytic tinning line handles the same 14-in. width, which seems to be standard. I was not able to determine why they prefer the narrower to the wider widths.

The tinning line also brought out a gold-colored product. They said it was electrolytic tinning but I imagine it is something else. However, we were unable, due to the language difficulty, to find out exactly what it was. It was golden in appearance, a very pleasant and nice looking sheet. I bent one of the pieces a great many times without any parting or crazing becoming evident. This electrolytic tinning line, as they call it, was producing at the rate of 2 tons per hr.

**The Russians Themselves**

These people are determined to make a better way of life for themselves and they seem to be making progress. My observation is that they use a great deal more labor on most jobs than we would find necessary. Everyone seemed to be

working at a good rate of speed and no one stands around with nothing to do. Supervision seems to be of a high order.

The impression I have about their standard of living is that everyone seems to have ample food and clothing, although the clothing is of a coarse and uninteresting type. Their shoes seem to be well-built. They all look muscular and none seem to be underfed.

We noticed a great lack of salesmanship and advertising. There doesn't seem to be any effort to sell anything. In fact, there are only about three or four neon signs in all of Moscow and Moscow is a city nearly as large as New York. There are no windows for the ladies to window-shop. People queue up to buy things and know what they want to buy before they go.

The people, however, seem to be happy. I have often been told that the Russians are sullen and unhappy, but we did not get that impression. Most of the people we saw on the streets seemed to be normal and well-mannered people. Their appearance is rough and they undoubtedly do much more manual labor than we do in the States. All in all, they are a nice-looking group of folks who seem to be getting along fairly well and are content with their situation.

All the Russians we met were sincerely anxious to be friendly with the American people and wanted to promote a lasting friendship. In fact, we didn't find a single Russian who didn't appear to like the Americans and who didn't hope that there would never be any difficulties between our two countries.

# Russians Discover Spark Cutting

**Pressing and forming dies of chromium steel are formed with brass or copper-graphite tools, usually in three stages. Reconditioning of dies is also recommended. A very thin but very hard, wear resisting layer on cutting tools and machine parts is produced by sparking dry while vibrating the contacts continuously. (G 17).**

A DOZEN OR MORE Russian publications on cutting, forming and hardening of metals by electric spark techniques have become available to the West during the past two years. These date from 1947; a translation of the most recent ("Working Metals by Electro-Sparking," by A. V. Nosov and D. V. Bykov) has been printed by the British Government's Department of Scientific and Industrial Research, and is available from Her Majesty's Stationery Office, London, for 6 s. or 85¢. It contains a fairly comprehensive statement of the fundamental principles, the necessary equipment as made in U.S.S.R., and the operational routines. A final chapter indi-

cating the extensive use of "engineered units" in Russia leads the British translator to surmise that "the main reason for their current interest is the severe shortage of strategically important diamond bort in Russia", such as would be necessary for cutting or grinding hard carbide tools.

Even though that may actually be the principal use of the process in Russia – proposed by the way, "during the Great Patrotic War by Soviet inventors B. R. Lazarenki and N. I. Lazarenko,*" as noted at the very outset – very little is said about shaping of hard tool materials. If the pamphlet is to be believed, electro-sparking is used in Russia principally for sinking and conditioning dies. The workpieces discussed are mostly low-chromium steels roughly approximating A.I.S.I. 5120, 5140 and the ball bearing steel 52100 and a high-carbon high-chromium analysis called "Sormite" (1.75% C, 15.5% Cr, 2% Ni, 2% Si).

Perhaps the true situation can be guessed from this quotation from the introduction:

"This is an extremely effective method of working metals. With its aid not only can working to close dimensions of metals be carried out but also a great improvement in the quality of the surface layers can be obtained, which is of importance in prolonging the life of expendable parts. The electro-sparking method is particularly effective in working metals or alloys of great hardness. By employing this method it is possible to save in labor and to carry out work without using expensive tools, which are in short supply.

"The field of application of the electro-sparking method of working metals is very wide. It is possible with its aid to cut and polish various metals and alloys, cut blind and through holes of various diameters, produce press-tool dies, carry out copying and engraving operations, sharpen tools fitted with cutting edges of hard alloys, and effect all sorts of repairs.

"Owing to the technological possibilities and high efficiency of the electro-sparking method it is now widely used in State industries. It is also important to introduce the electro-sparking method on a large scale into workshop practice in industrial cooperative societies engaged in working metals. In Moscow alone there are up to 70 metalworking shops in the City Industrial Soviet which every year use tools and various press-tool dies to the value of several million rubles. The application of the electro-sparking method would enable the workshops to lower industrial expenditure and, at the same time, to raise the quality of the finished product."

### The Shaping Tool

As is well known, the erosive effect of repeated electrical discharges between tool and workpiece removes metal from the latter. The tool, so-called, does no actual abrading itself but acts only as an electrode; theoretically, its principal requirements would be electrical and heat conductivity, and cheapness. It also is eroded away by the electrical action, and consequently the material should be inexpensive and readily worked into the required form. Some experiments on the "comparative machinability of a plain carbon steel with tool electrodes of different materials" lists the tool materials in the following order:

| | |
|---|---|
| Brass (62% Cu, 1.5% Pb) | 0.3 |
| Pearlitic cast iron | 0.5 |
| Phosphor bronze | 0.7 |
| Copper | 0.7 |
| Brass (59% Cu, 1.5% Pb) | 1.0* |
| Copper-graphite mix | 1.5 |

*Basis of comparison

"The wear on the tool, depending on the working conditions and nature of the material of workpiece and tool, ranges from 20 to 250% of the volume of metal removed from the workpiece."

Erosion resistance is another factor of importance – erosion of the tool from the sparking action, that is. The coefficients showing relative wear line up the tool materials in a somewhat different order:

| | |
|---|---|
| Brass (59% Cu, 1.5% Pb) | 1.0 |
| Brass (62% Cu, 1.5% Pb) | 0.84 |
| Phosphor bronze | 0.69 |
| Pearlitic cast iron | 0.38 |
| Copper | 0.37 |
| Copper-graphite mix | 0.30 |

Obviously a single tool material cannot satisfy three basic requirements simultaneously – maximum efficiency, minimum wear, minimum cost. The Russian pamphlet says that tools made from copper-graphite mix, the leaded brass with 59% copper, and pure copper are to be preferred, although in many shops gray cast iron is used. One assumes that tools of only the simplest form, readily made in the shop, can be expended at the high rates quoted. The pamphlet says that tools with complex profiles or contoured ends are best made by casting, although stamping is also to be preferred over forging or machining methods.

Preparation of the copper-graphite tools is described as follows:

"The mix comprises copper 85%, aluminum

*Tweedle-Dee and Tweedle-Dum (?)

2.5%, well-wetted graphite 2.5% and a cement* 10%, carefully mixed with water to bring it to the consistency of a paste. The mix is poured into a press mold and compacted under a pressure of 7 to 10 tons per sq. in., excess water is forced out and the mass reduced in volume to about 40% of its original. The formed tool, having a mirror-like surface and high strength, is in no way inferior to a tool made from the usual copper-graphite material in respect to wear resistance and efficiency."

A new tool material known as "BKE" is a binary alloy of copper and cadmium, containing 3 to 4% of the latter, and is said to wear at about one quarter the rate of the best brass and remove about 25% more material.

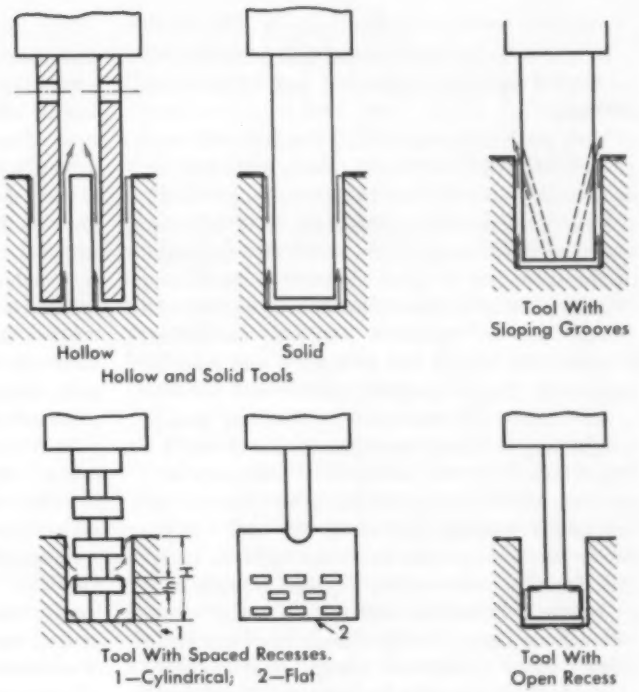



*Fig. 1 — Suggested Design of Tools for Broaching Fairly Large Holes in Workpieces*

### Working Methods

The electrical equipment provides a circuit in which the component to be worked and the working tool are the positive and negative electrodes between which impulse discharges occur rapidly. For electro-sparking machines working within the range of 36 to 220 volts, the spark is caused by the discharge of condensers arranged in parallel with the electrodes, which, in turn, receive their energy from a direct current supply. The spark has a duration of $10^{-8}$ to $10^{-4}$ sec.

The electrical conditions vary with the requirements of the job, principally the rate of removing the metal (fast to slow) and the surface finish left behind (rough to smooth) — the two factors being linked in the order stated. Conditions for finishing dies for medium sized forgings (weighing, say 5 to 10 lb.) which have already been rough machined to within 0.075 in. of finished size are quoted as follows:

| | Volts | Amp. | Capacities† |
|---|---|---|---|
| Coarse | 100 | 10 | 100 |
| Medium | 100 | 5 | 50 |
| Fine | 100 | 3 | 10 |

On the other hand, if a flat block is to be electromachined to a given impression, the electrical conditions might be something like this:

| | Volts | Amp. | Capacities† | Duty |
|---|---|---|---|---|
| Coarse | 150 | 2.5 | 25 | Down to half depth |
| Medium | 120 | 1.5 | 5 | 50 to 75% depth |
| Fine | 80 | 1.0 | 2 | Finish |

As is noted in another place, three different tools of increasing surface smoothness and dimensional accuracy would be used.

When broaching moderately large holes — round, square, hexagonal or complex shaped — the tools are conveniently cut from extrusions. Such holes might be cut with currents of 220 v., 22 amp. and 300 microfarads. Suggested tool shapes for larger holes are shown in Fig. 1. If the workpiece is machinable by ordinary machine tools, it may be economical to go to "lead and follow" methods, where a drilled hole is broached to shape electrically.

In any event, the user is warned that deep holes will have smaller dimensions at the exit or bottom end, due to wastage of the tool enroute. The taper angle may be as much as 1° 30′. A follow-through with a tool having a clearance of 0.005 in. with low electrical voltage will cut this taper to 0° 20′.

*The "cement" is probably a nonmetallic, self-setting material, since the compact is used as-pressed, and not sintered (as the plain copper-graphite mix would be).

†Microfarads

It is also noted that curved holes can readily be drilled by electro-sparking, but by no other method.

Very small holes would be broached with even smaller electrical impulses. For a hole 0.01 in. in diameter (material in workpiece unspecified), the electrical conditions might be 40 v., 0.3 amp. and 0.05 microfarad. It is noted that agitation of the dielectric by such currents is insufficient to sweep away the metallic debris, so the tool should be in constant vertical oscillation. Furthermore, such a fine wire for a tool must be supported; fine glass tubing serves well for this.

All known electro-spark operations, except toughening or strengthening, are carried out in a liquid which separates tool and workpiece and prevents the disintegrated particles from adhering to the working surface of the tool. Experience has shown that the most suitable materials for this purpose are organic liquids such as kerosene or transformer oil. In some cases, water is used even though the speed of removing metal (other conditions being equal) is only about half what could be expected if oil were used. The Russians recommend water whenever the fire risk is great, or in those rare instances where any carburization of the finished surface must be avoided.

**Dies for Presses**

Six pages of the Russian pamphlet are given over to the production of dies for press tools. Although no mention of the die material is made the operations are likened to the formation of a blind hole of irregular depth and width. Hand work in the die shop is replaced by mechanization and costs are reduced. Electro-sparking is particularly recommended for reconditioning slightly worn forging and stamping dies after the face has been ground down a small distance.

In general, three different sized tools are needed for roughing, semifinishing, and finishing, corresponding to coarse, medium and fine electrical conditions of working. In repetitive production of dies, the tools used in working for the final and median stages can be used for coarse working after suitable truing by filing. The size of the roughing tool, in plan, is 0.010 in. less than the corresponding dimensions of the die impression, and the semifinishing tool is 0.001 in. less. (These very close tolerances indicate that it might cost just about as much to make the die by conventional methods as to make the finishing tool.) The largest dimensions of the finishing tool should not exceed those of the impression profile, less the allowance for hand finish plus the lateral clearance for the final electro-sparking operation.

Much emphasis is laid on the increased durability of dies so made – as much as two to two and a half times the life of punching and shearing dies. This is due to two causes: Dies made by machining are cut into soft or annealed die blocks, and when these are subsequently heat treated, a thin, partly decarburized layer of deficient hardness results. (Evidently the ordinary die shop lacks modern heat treating equipment and atmosphere controls.)

In the second place, electro-sparking can sink into a fully hardened die block and furthermore, the spark usually goes through a film of kerosene, which is momentarily decomposed and furnishes a carburizing medium for the working surface of the die. This is strengthened and toughened by the formation thereon of a considerable amount of iron carbide. No subsequent heat treatment is necessary, and thermal damage is avoided which is especially important to combination or compound dies which have thin sections in the working impression.

**Toughening of Surfaces**

This extra hardness and wear of electro-sunk die surfaces has led to extensive use of a new process for hardening and toughening of surfaces, whereby superior wear resistance is given to machine components and even to cutting tools.

No liquid is used in the toughening process. The article to be toughened is the cathode, and the other electrode (hard metal* or graphite) is the anode in the usual electro-spark arrangement. The two fit fairly closely; electrical discharges (in air) pass between tiny peaks or asperities on the abutting surfaces. During the process the two contacting surfaces are vibrated by an electro-vibrator whose armature is attached to the positive electrode, and are constantly moved a small distance laterally by hand. If the toughened part is a surface of rotation, the equipment may be attached to a lathe.

To appreciate the metallurgical aspects of this operation it would be well to return to the sparking action itself. Each discharge leaves on the surface of the workpiece a trace or mark in the form of an indent (lune) of irregular form and

*"Hard metal" is defined as a material based on tungsten carbide and cobalt, with or without titanium carbide.

from 0.03 to 0.3 of its diameter in depth. The energy of the discharge rises with increasing capacity at constant voltage, and accordingly increases the depth and diameter of the lunes which eventually leads to a poorer surface finish. The strength of the charging current shows much less effect on surface finish. The electrical conditions (principally voltage) are adjusted so the finished surface of the machined part will not be damaged for service.

During electro-sparking, the surface layer of metal undergoes drastic structural changes. The heat developed under discharge partly melts and vaporizes a certain amount of metal. The adjoining superheated metal is quite reactive, and in "dry" sparking absorbs nitrogen from the air, which diffuses inward according to the temperature gradient. Subsequently the hot spot drops almost instantaneously in temperature from a few thousand degrees to its normal value; this markedly hardens the surface layer in the zone of discharge activity, both by the formation of martensite with the carbon already in the analysis, or by the break-up and finer dispersion of excess carbide particles, and by the strain hardening of an intense quench. As a result of these changes, a whitish layer is formed on the surface of steels with a high degree of hardness, wear resistance, and relatively good corrosion resistance. On the debit side, it has been found that the fatigue strength of a component is appreciably lowered where this white layer has formed.

The thickness of the white layer, depending on the operating conditions and composition of worked material, ranges from 0.01 to 0.04 mm. (0.0004 to 0.0016 in.). Below the top hardened white layer is an annealed layer varying in thickness from a few hundredths of a millimeter to 0.4 mm. (0.016 in.), whose hardness, compared with that of the white layer, is lower by 200 to 300 Vickers units, depending on the type of steel being handled.

The toughened layer is hardly affected by the usual etching agents, but owing to its thinness it cannot serve as an anti-corrosive coating. Furthermore, the toughened layers cannot be subjected to further mechanical treatment; the surface can only be finished with boron carbide using cast iron laps, or fine-grained abrasive tools.

"The quality of the toughened layer also depends in large measure on the initial composition of the surface of the article. Any appreciable roughness or rust or dirt on the surface is quite harmful. The clean surface should be dusted with a powdered flux before treatment (95% colophony, 3% potato starch, and 2% potassium nitrate), and the following electrical conditions are adopted: potential 24 v., capacity 35 microfarads, current 5 amp.

"The quality of the toughened layer is largely determined by the duration of the process. With prolonged treatment at one part of the surface, single dark spots begin to appear, indicating incipient breakdown of the toughened layer. Completion is usually determined by the outward appearance of the spark which gradually loses its brilliance and form; this is followed by the appearance of the defective spots."

The process may well be applied to tools made of high speed or high-carbon steels prior to working on hard cast iron, austenitic steels or other metals of difficult machinability.

"The life of the toughened tool is actually increased from two to three times. Considerable value is also observed in toughened tools for intermittent machining such as planing or slotting. A tool working at high speeds and small chip section on soft constructural steels or on finish machining is not usually improved. After toughening, a tool should be finally ground and finished, and should be re-toughened after each grinding. Those surfaces of the tool exposed to greatest wear should be treated. It is especially important that the cutting edge of the tool is not touched or affected by the discharges. Begin work at the central part of the surface to be treated, proceeding gradually toward the cutting edge, but stop just short of it."

For tools needing a high degree of accuracy, such as gage jaws, a graphite electrode is recommended; for less accurate tools, hard metal electrodes suffice.

Estimates of the economic factors for tool toughening are given as follows:

Cost of plant for economical working: 1000 to 3000 rubles.*
Power required: 0.8 to 1.2 kw.
Grade of worker: 3rd or 4th class.
Time per 1 sq.cm. surface: 0.5 to 3 min. according to electrical conditions (3 to 20 min. per sq.in.).
Duration of toughening of one cutting tool per treated area of 15 sq. mm.: 3 to 5 sec.
Consumption of electric power per 1000 tools of section 16 by 25 mm. (0.63 by 1.0 in.): 1.2 to 1.5 kw-hr.
Consumption of hard metal per tool: 2 to 5 mg. (14,000 to 36,000 per oz.).
Increase in life of tools: Up to 350%, according to conditions of use.

*$250 to $750!

# Induction Heating for Stress-Relieving Large Steel Cylinders

*By G. W. SEULEN**

**Portable equipment in 100-kw. packages, converting line frequencies to 2000 or 10,000-cycle current, can efficiently and accurately heat treat welded seams in pipe and pressure vessels using built-up inductors (water cooled) or uncooled copper cable. (J 1, J 2, ST)**

IN EUROPE, there has been a consistent trend toward ever-higher working pressures in pressure vessels, boilers, pipelines, and penstocks. Furthermore, construction of these large important items is almost exclusively by welding. Increasing attention is therefore being given to the quality of the welds. Besides X-ray inspection for weld defects, cracks and blowholes, heat treatment of the welded joints – including the heat affected zone in the base metal – is very often required, in the field or on the site where large furnaces do not exist. Depending on the composition of the steel, its wall thickness and stress condition at the weld, the heat treatment may consist of preheating before welding at 350° C. (660° F.), stress-relieving after welding at 600 to 650° C. (1110 to 1200° F.), or normalizing at about 920° C. (1690° F.).

Formerly portable gas burners were used for these heating operations, but electrical induction has gained acceptance in recent years, especially since it is now easy to get the desired temperature cycles under close control. In induction coils, the heat is produced in the very sections which are to be heated without any necessity of conducting it into the piece through electrodes or by flames bathing the surface. The area to be heated can be conveniently surrounded by a coil which is fed by a current of suitable frequency and power.

While massive steel forgings or castings of variable cross section can be heat treated in this manner, the present article will confine itself to the commonest operations, namely, the heating of circumferential joints in pipe of large diameter, say, 6 in. and over. Line frequency of 50 to 60 cycles per sec. seems easiest, but experience shows that the use of medium-high frequencies of 2000 to 5000 cycles offers many advantages. Line frequency needs on-and-off controls to regulate the energy imput so as to stay within the prescribed temperature cycles for heating, holding and slow cooling. With medium-high frequencies, on the other hand, input can be controlled continuously by regulating the excitation of the generator. Furthermore, the number of turns necessary to transmit the same effect at the same voltage is considerably smaller – one quarter or less – so the coils (consisting of split water cooled copper windings or cable) are easier to construct. This is especially important when the welds are located in awkward or difficult places and the energy must be supplied through longer cables. Other conditions being equal, the cable losses are lower with medium-high frequency than with line frequency on account of the lower required amperage. Finally, when annealing joints in big pipe lines (up to 18 ft. diameter and 1.75 in. thick), the power is more uniformly drawn from each of the three phases of the feeder line.

Since the heat is generated *within* the pipe wall, uniform temperature is attained throughout

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the wall in shorter time by induction heating than by the older conventional annealing methods which supplied the heat through the exterior surface. For instance, when normalizing 1.5-in. plate, the temperature difference in the heating zone between the exterior and interior surfaces is only about 20 to 35° F. at the end of the heating cycle. Consequently the annealing time can be cut, and this means that specified procedures must be changed. Normalizing cycles in large furnaces required, for example, that the temperature of 920° C. be maintained for a period of 1 min. for each millimeter of wall thickness (25 min. per in.)

**Table I – Electrical Power for Various Operations**

| Electrical Unit | | Wall Thickness | Diameters | |
|---|---|---|---|---|
| Output, Kw. | Frequency, Cycles/Sec. | | For Stress Relief | For Normalizing |
| 10 | 10,000 | 0.12 to 0.75 in. | 0.75 to 7 in. | 0.75 to 3 in. |
| 50 | 10,000 | 0.25 to 1.0 | 0.75 to 50 | 0.75 to 20 |
| 100 | 2,000 | 0.5 to 1.5 | 2 to 100 | 2 to 40 |
| 2 of 100 in parallel | 2,000 | 0.5 to 1.5 | 2 to 100 | 2 to 80 |

The diameter and wall thickness of the pipe to be heat treated are the deciding factors which determine the electrical capacity needed. The area to be annealed should be effectively insulated in order to avoid convection losses and, to a lesser extent, radiation losses. One can estimate, theoretically, the specific input required for piping of given size, making certain assumptions concerning heat transfer to surrounding air over an adjacent metal, but in practice the inductor requires 10 to 14 times the theoretical input. For the heating cycle, substantially higher specific capacities are obviously required than for maintaining the temperature.

These requirements determine the size of equipment. Empirical values have been recorded in Table I on the basis that at least a 3-hr. heating cycle will be required for heavier pipe lines. Wall thicknesses greater than shown in the third column require higher capacities than indicated.

Since the heat treatment usually must be performed on the site, the equipment must not be excessively bulky or heavy. For this reason, two or more units of 100 kw. each are preferably connected in parallel to heat treat joints which require more than 100 kw. To stress-relieve a 15-ft. pipe of 1.5-in. wall, for instance, two 100-kw. units suffice. Correspondingly, a pipe of even greater dimensions requires three.

Equipment for the heat treating of welded joints consists essentially of a portable medium-frequency converter with its connections, line switches, condenser battery and connections, including instrumentation and controls. For sizes up to 50 kw., which are large enough to stress-relieve pipe up to 4 ft. in diameter, all components are frequently assembled in a small van, switches and instruments mounted on the rear-end panel behind a sliding door, while the converter, condensers and switches are inside the van body casing. Over-all dimensions are on the order of 6 ft. wide, 9 ft. long, 7 ft. high, including 2-ft. wheels, and gross weight about 11,000 lb.

For greater capacity, it is preferable to use two 100-kw. sections, one of which includes the converter and line connections and the other, the condensers, secondary connections, instruments and controls as well as pyrometers and temperature controllers. Both should be mounted on sturdy trucks, from which they can be lifted by a crane.

Figure 1 shows the arrangement of the control panel. Besides the instruments for the medium-frequency output, generator voltage, generator current, field current, inductor and compensation current, and the temperature recorder, program

*Fig. 1 – Instrument Panel.* a, a *are three-phase medium-frequency controls for two converters,* b *is a six-position temperature recorder capable of operating to any given time-temperature templet,* c, c *are push buttons and indicating lights, and* d *is input control*

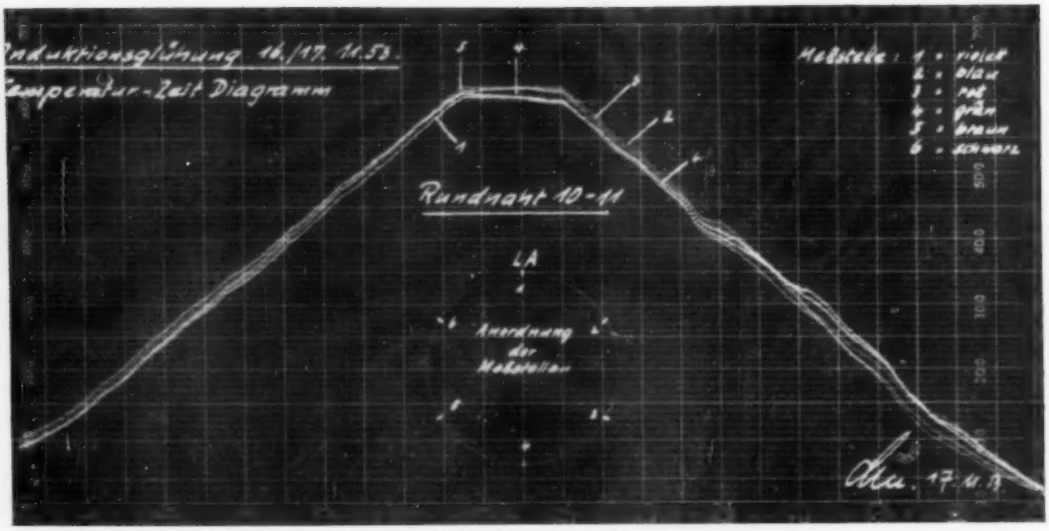



*Fig. 2 — Pyrometer Record of Stress-Relieving Treatment on a 15-Ft. Conduit. Six equally spaced pyrometers show close agreement throughout the 13.25-hr. cycle*

controls can be installed to regulate the time-temperature cycle of annealing. By inserting curved templets, the program controller provides fully automatic regulation of the heating cycle, the holding period and the cooling cycle.

Through this sensitive regulation, steep or gradual time-temperature curves can be followed at will with the greatest accuracy, as shown in Fig. 2, a time-temperature record for a stress-relieving operation at 1150° F. on a circumferential weld in a 15-ft. pipe of 1.25-in. wall thickness. The heating required 6 hr.; after holding for 75 min., the retarded cooling occupied the next 6 hr. Six thermocouples uniformly spaced around the circumference transmit information to the recorder, while the electrical input from the two 100-kw. 2000-cycle generators connected in parallel is regulated by the controller following the edge of an inserted program templet. Figure 2 shows the great uniformity of the temperature over the entire perimeter at all times, and the chart is permanent evidence of the accurate performance.

The coils are adapted to the structural shapes and pipe sizes encountered. For annealing joints in big pipe lines, the only practicable cables are flexible and asbestos insulated, often of hollow water cooled construction. They are operated at either 250 or 500 volts, and are directly connected to the medium-frequency outlets, or through an extension cable.

The joint is first covered with one or more layers of woven asbestos cloth. The cable is also wrapped with a single layer of cloth tape. The distance between the individual turns is chosen so the desired width of the pipe to be

*Fig. 3 — Inductor Coil of Flexible Cable* (a) *for Annealing Butt Joint in 8-Ft. Pipe. Three layers of asbestos blanket indicated by* b; c *represents leads to a thermocouple junction;* d *is a wire to hold down the blanket*

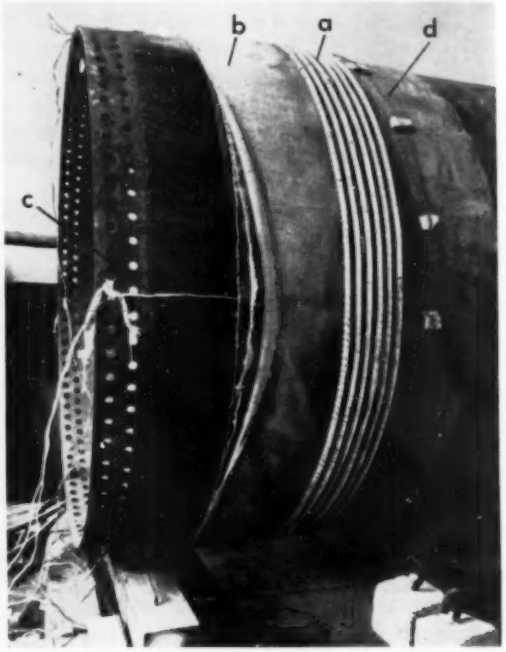


*Fig. 4 – Oval Inductor Made of Water Cooled Copper Pipe for Annealing Return Bends in Heat Interchange. Pipe is 4 in. diameter, 0.37-in. wall*

annealed, including the weld joint and heat affected zone, is exceeded by about 50%. Only on pipe of small diameters, where the entire cable length cannot be accommodated in a single layer of close-coiled windings, is the excess length coiled in a second layer on top of the first.

Such cable has a relatively short life, since any noncooled wire is heated to 650° F., a temperature which destroys the insulation and oxidizes the copper fairly rapidly. For the preheating of pipe ends prior to welding and for stress-relieving, 20 to 30 heatings is about the life of a noncooled cable. The water cooled cable lasts two or three times longer. They must also be used exclusively for normalizing; temperatures (1700° F.) are too high for noncooled cables. Actually, on account of their longer life, water cooled cables are frequently used for the lower temperatures of preheating and stress-relieving. For pipe diameters under 4 in., water cooled cables are too stiff to be used.

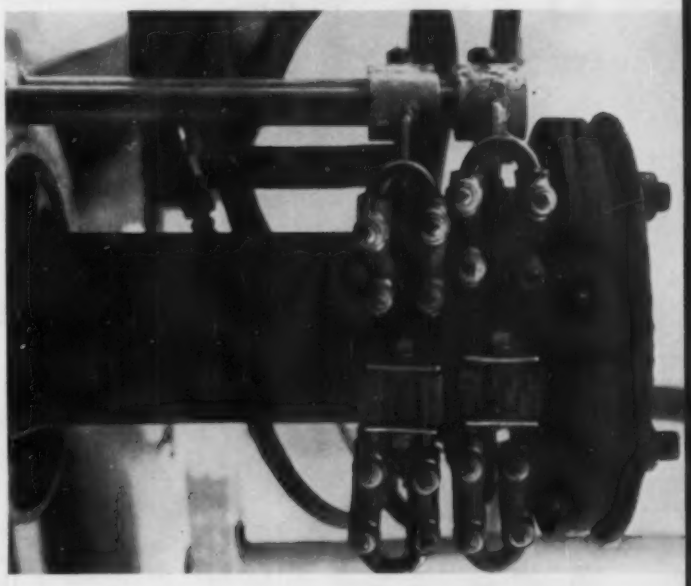
Instead of absestos insulated cables, bare copper braids can also be used for large pipe lines if the braids are wound on insulating bricks with properly spaced grooves, and evenly distributed over the external perimeter. Installation of these coils is somewhat more difficult and time consuming. In addition, the whole area must be suitably blocked off for the safety of personnel.

Figure 3 shows the installation of an asbestos insulated copper cable inductor for annealing of a hoop weld in an 8-ft. pipe. It also shows the arrangement of thermocouples; they lie under the first of the three absestos blankets. An accurate recording requires careful installation. They must end close to the surface of the joint – in fact, may be spot welded to it. Experience has shown that the thermo-electric currents are unaffected by the medium-frequency field created by the inductor. The lead wires must be placed directly adjacent to each other in pairs or triplets. Furthermore, the leads to the heating coil should lie close together in order to minimize self-induction and a resulting voltage drop. The work should always be carefully grounded to avoid hazards to the operating personnel if a short circuit should occur between coil and steel.

For the annealing of joints in smaller or medium diameters, as found in the steam and superheater loops of boiler installations and in pipe lines in the chemical and synthetic gasoline industries, permanent inductors are commonly made of water cooled copper tubing. Depending on the configuration of the connection and the accessibility of the area, the inductors are either one-piece round or oval loops or two-piece snap-on coils.

Figure 4 shows a single-piece oval coil for annealing return bends in a synthetic gasoline plant. It is composed of six water cooled oval

*Fig. 5 – Two-piece Inductor Behind Flange in 6-In. Pipe*



copper windings and has wooden blocks and a handle to slide it in place. There are hose connections for inlet and outlet water and electrical terminals. The internal face of the inductor is plastered with heat insulating material which must be renewed after 30 to 40 annealing cycles. The individual coil turns themselves are wound with ribbon woven of glass fiber, then drenched with bakelite or silicone lacquer and baked. This results in fully adequate insulation, entirely safe for the operating personnel. Although such a conductor of oval coils only acts on the outer half of the two welds, conduction will give a sufficiently uniform temperature over the entire perimeter.

When the joints lie behind flanges or other locations which are inaccessible to a one-piece permanent conductor, two-piece snap-on permanent conductors of various designs may be used. For example, a fixture attached to a pipe threading lathe is shown in Fig. 5; it is used to treat a weld located behind a flange. The two halves are slipped over the pipe and then bolted together to insure flow of current between the mating half-turns. Conforming spacers insure the concentric position of induction coils and joint. Cooling is so arranged that the water flows through coils in each half successively, but not from one half of the inductor to the other. In such an arrangement each conductor is wound with woven glass ribbon, and the area to be annealed is wrapped with asbestos cloth.

*Fig. 6 – Two-Piece Annealing Inductor for 10-In. Pipe in Open Position*

a. *Six inductor half-windings*
b. *Knife contacts*
c. *Tension bolts*
d. *Tension nuts*
e. *Holding blocks*
f. *Inductor holder*
g. *Handle*
h. *Cable contact slots*
i. *Water line for cooling*

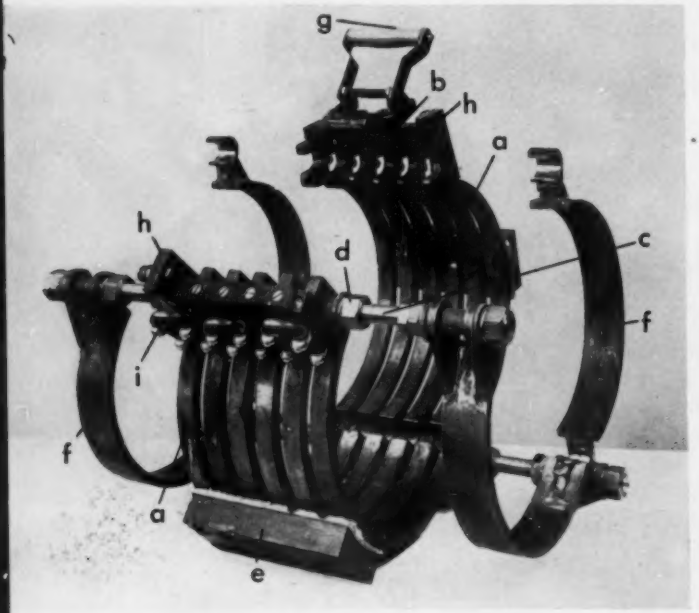



Figure 6 shows a snap-on inductor for the pipes of 10-in. diameter and 0.5-in. wall. The contacts *b* are like self-cleaning knife switches. Necessary contact pressure is attained with nuts *d* screwed on the tension bolts after the inductors have been closed. Sidewise contact of the mating surfaces prevents warpage of an individual turn. They are given geometric stability by two wooden blocks spanning the windings as well as by the two retaining bolts made of stainless steel. These bolts simultaneously hold the snap-on fixtures *f, f,* which grip the pipe on both sides of the weld to be annealed. The inside diameter of these holders is about 1 in. smaller than the bare windings, thus preventing contact between the live inductor parts and the pipe.

Cooling water flows in series through the six half-turns. A handle serves to close and open the fixture. The current carrying cables are connected to the contact slots *h, h* on both sides of the inductor. The weld joint is wrapped with asbestos cloth.

Tubular induction coils with a few turns frequently require a lower voltage than can be had from the medium-frequency equipment. In such instances, they are connected through taps on an intermediate transformer which also may be constructed as an auto transformer. Voltage adjusted to the size and number of turns of the inductor may be selected within wide limits. Since the transformer is part of the secondary circuit, it is designed for full rated capacity; its windings are made of water cooled copper tubing. To simplify the water connections, the transformer and the inductor are usually connected in series – an obvious arrangement, since the two are located as near together as possible to avoid unnecessary line losses.

In summary, the advantages of inductive preheating or post treatment of welded joints in pipe lines and large pressure vessels lie in the simple handling and the automatic temperature control of the heating, holding and cooling cycles, as well as in the adaptability and easy installation. The method is especially suitable for circumferential welds; however, when medium frequency is used, longitudinal welds can also be stressed-relieved in a faultless manner. The method is widely used in the industrial regions in Free Germany and Western Europe.

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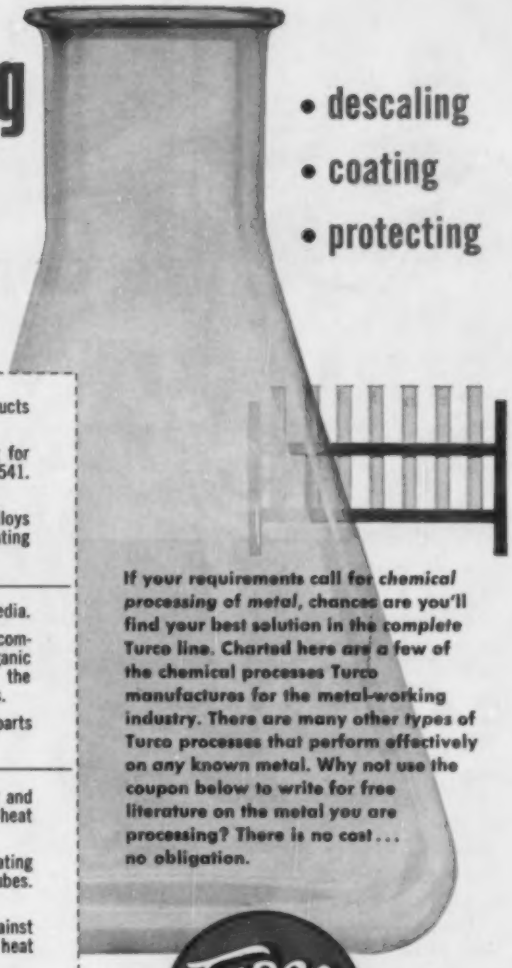

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| **STEEL** | **DESCALING:** Complete line of alkaline and acid descaling media.<br>**COATING:** Full line of iron, zinc and manganese phosphate compounds to provide a tight coating for better adhesion of organic finishes and for oil absorption. These materials all meet the various requirements of applicable government specifications.<br>**PROTECTION:** Versatile group of products for protection of parts from the elements. |
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# Correspondence . . .

## Heat Treatment Operations in Mexico

CLEVELAND

Recently, I made a trip to Mexico to determine the potential market for induction heating equipment that may develop with the continuation of the present industrial expansion. The results were discouraging because power is limited, quality control is virtually unheard of and labor is paid a ridiculously low rate. However, I thought that readers of *Metal Progress* would be interested in my findings.

One company which was considered to be a likely prospect for induction equipment manufactures deep-well pumps and transmissions and plans to produce piston pins, rings and valves. It has a foundry melting about 8000 lb. of iron and steel per day which employs about 100 men. A cupola furnace is used for melting and it is charged with any kind of scrap available including structural shapes, automobile and truck parts, engine blocks and anything else they can find. The semi-skilled labor rate is $1.25 per day which appears to be about what the laborers are worth.

The cupola has an electric blower and occasionally when it is fully charged, the power goes off. The power company can never say when power will be restored; it may be a few minutes or a few days or even longer. The plant engineer sits around biting his nails hoping the power will come back on until he finally has to dump the charge from the furnace so it won't freeze. Such an occurrence is quite common and anyone in Mexico who relies on power for production is at the mercy of the power company.

This company plans to manufacture the gears used in its products because it now must pay a 40% import tax on those they use. A Tocco unit is being considered for heat treating the gears but I shudder to think how we could possibly set cycles in view of the variation of material from which the gears would have to be made. The low rate of production, unreliability of power and the carefree attitude of the workmen would help make induction heating most uneconomic here.

Gears are now manufactured by another firm I visited, which also makes gear motors and gear reducers. The raw material has a hardness of about Brinell 300 and the company is considering the purchase of hardening equipment, either flame or induction, to harden the gears to Brinell 350 after machining. The new specifications call for cast steel equivalent to S.A.E. 1050 hardened to Brinell 350. I pointed out that the 1050 would quench to a much higher hardness and that it would be necessary to draw after hardening. I recommended that they consider a steel with 0.30 to 0.35% carbon if only Brinell 350 was needed. I was advised, "Oh, sometimes the 1050 steel has only 0.30 to 0.35% carbon as we get it." The company seems to feel that there will be a growth in the local steel-producing industry and that sooner or later, the producers will learn to make good steel.

The same disregard for quality control was apparent in the operations of a manufacturer of plumbing hardware consisting of brass sand castings, zinc and brass die castings and cast iron tubs. In the foundry, I watched an operator scrape the metal clean in a furnace and pour into a ladle which was then placed on the floor while the slag was again scraped from the surface of the metal. At that instant, one of the operators ran across the room and came back with a lump of bluish material which he dumped in the ladle. Then while it was still floating on top, they proceeded to pour into the mold. My host, the general manager, asked me if I saw what had happened and could I guess what the operator had done. I took a quick guess and asked if that was supposed to be their phosphorus addition and if so how did he expect it to get into the material that way. I was correct. The men can be instructed a thousand times to put the charge into the bottom of the ladle before they put in the melt and mix it, but they seem to forget. To them, how it is added or when doesn't seem to matter much.

I was told that the management had taken the average production figures for the last couple of years and discussed them with the union in an effort to increase production. They did not make a time study to set a bonus rate but agreed to pay extra for any production above what had been the average. This, all agreed, would not require too much effort on the part of the men. This incentive program was tried for about three weeks, during which the men actually didn't work any harder but were perhaps a bit more consistent in their motions and as a result picked up about a 20% increase in pay. At the end of that time, the

union came to management and advised that the men weren't interested and were perfectly willing to go along the old way. In other words, even if you can show them how to improve their earning capacity, they are apparently satisfied with the little they now have.

I learned that even though living costs have gone up 150% in the last few years, they can't seem to get the workers to understand they can make more if they will produce more. Believe it or not, a graduate engineer down there gets about $100 a month – and there are good ones. Maybe we should import some.

HARRY B. OSBORN, JR.
Technical Director, Tocco Div.
Ohio Crankshaft Co.

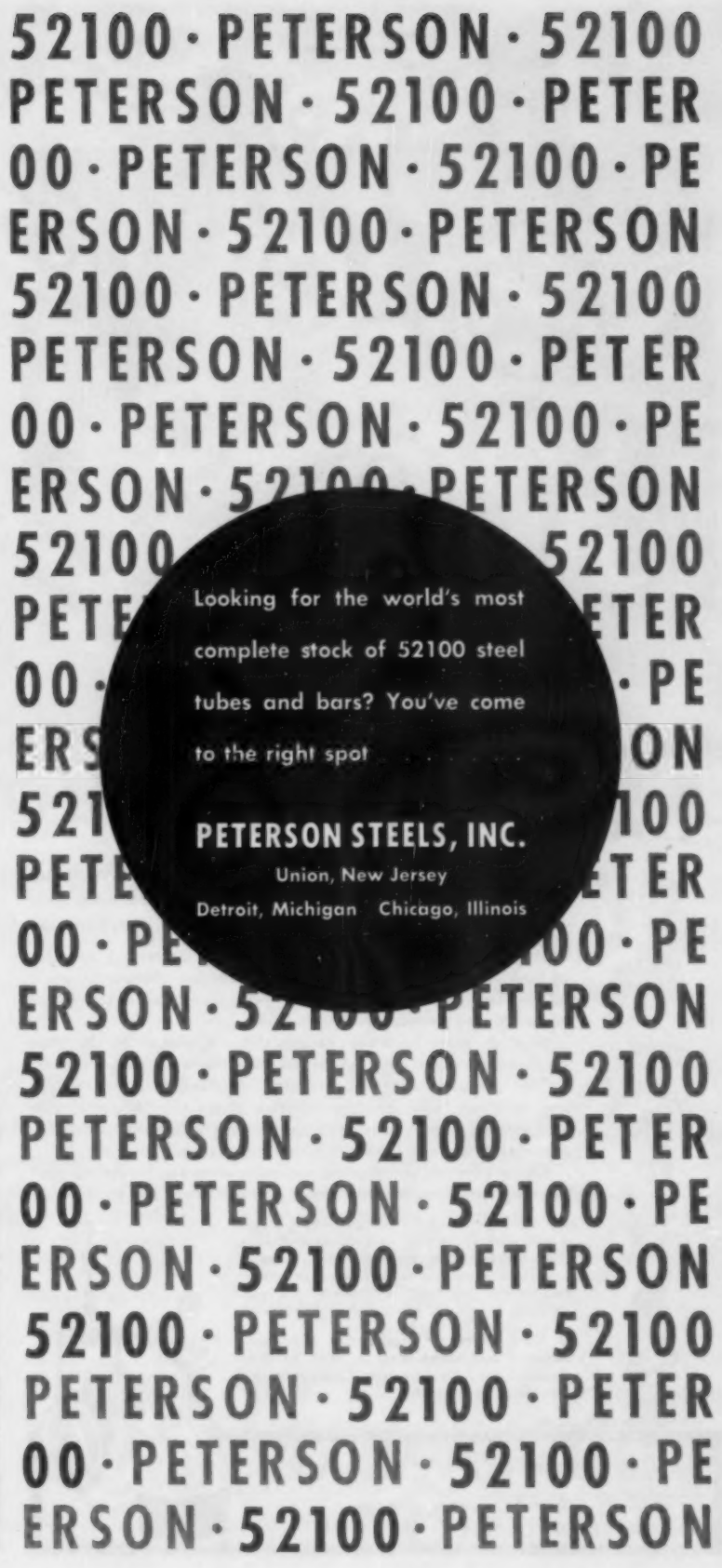
## Nickel Is Still Scarce

WASHINGTON, D.C.

Many segments of industry are learning to do without nickel, to make better use of nickel scrap and to use alloys containing less of this valuable metal. The current shortage of nickel makes this a wise course; the Office of Defense Mobilization has announced that nearly 80,000,000 lb. of nickel was diverted from the national stockpile to ease the shortage in 1956, and that no nickel at all will go into the stockpile during the first quarter of 1957.

The steel industry has made a strong effort to ease the current nickel shortage by stimulating a shift to a new stainless alloy using manganese to replace about half the nickel. This one substitution alone, if energetically pressed, would reduce by as much as 10% the national consumption of nickel. Stated another way, it would enable the nickel available to us to do just that much more work. The American Iron and Steel Institute has recognized the acceptability of this new stainless steel and has assigned it the type number 200 to distinguish it from the nickel-rich 300-series of stainless steels.

About one third of all nickel goes to direct military and atomic energy uses. All three military departments have told their designers to seek ways to replace high-nickel stainless steels in their equipment with the new manganese-type alloys, or with nickel-free stainless steels, or with aluminum, or plastics, or other non-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## Nickel . . .

nickel materials. National policy requires that military needs for nickel be met in full. However, fullest use of the substitute materials throughout all industry would also enable stockpiling to proceed and leave a more abundant remainder for civilian consumption.

I appeal to private industry to cooperate with the Department of Defense by looking for places to save nickel in equipment and civilian uses. If you in industry are resourceful in conserving nickel while producing soundly engineered products acceptable to the public, it will prove that in this country we can take practical measures to use materials more effectively, without dictation or regulation.

We will not in future years be able to afford the lush expenditures of minerals we are making today. As we grow wise, skillful and prudent in our use of these materials, it will help us to meet the challenge of future growth and still live within our national resources.

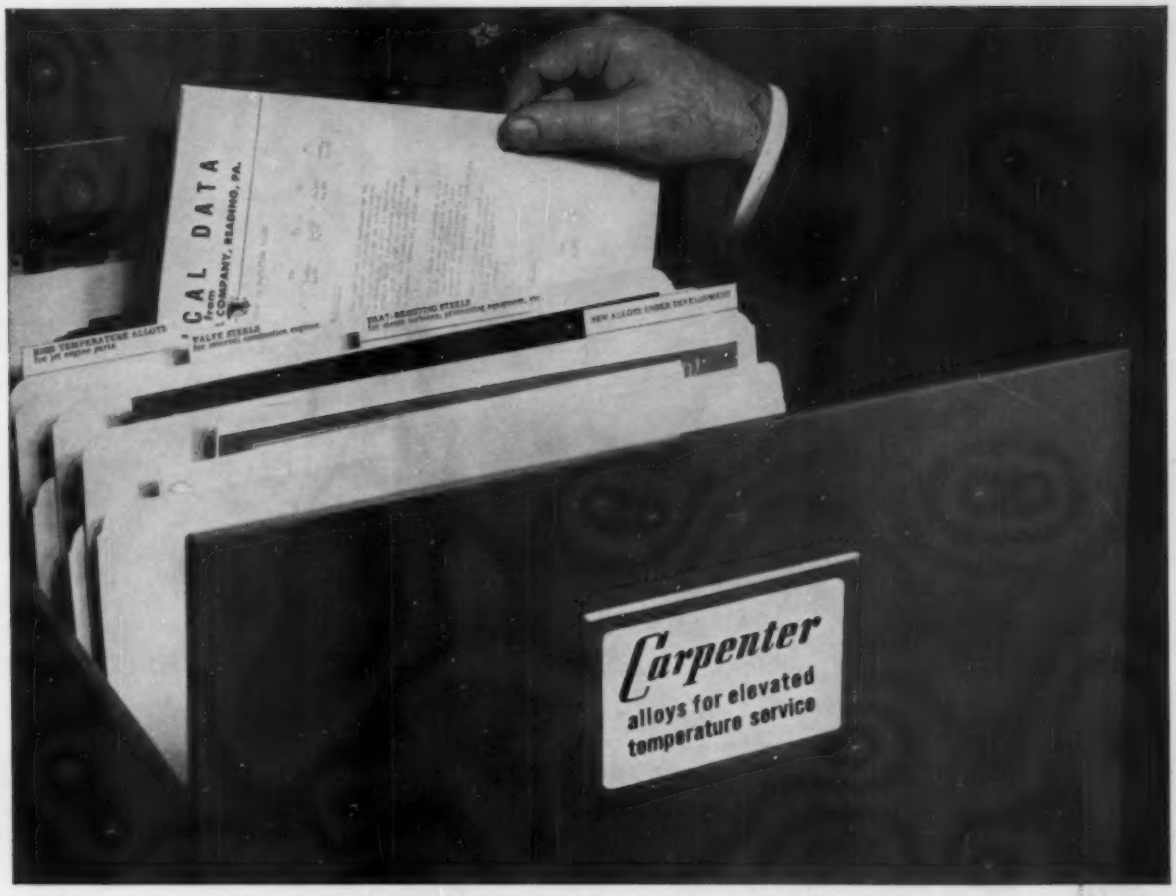
CHARLES E. WILSON
Secretary
Department of Defense

## More Metallurgists for Russia

CAMBRIDGE, MASS.

Readers of *Metal Progress* may be interested in a recent visit to this country by Dr. Alexander M. Samarin, deputy director of the Institute of Metallurgy, Academy of Science, in Moscow, U.S.S.R. Alex is an old friend of mine and a coworker in metallurgical research at the University of Michigan in 1935. He was in Canada earlier in the month looking into pneumatic processes for steelmaking, then came to this country for brief visits at New York University and Massachusetts Institute of Technology. The years have changed him but little, and he is still the same friendly, modest research worker I knew 20 years ago.

The interesting information that he left with me had to do with metallurgical education in the U.S.S.R. We talked a lot about the uses of radioactive tracers in steelmaking research and about vacuum

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## Russian Metallurgists . . .

technology and other subjects of consuming interest to us, but his information on the educational system is the point which hit me the hardest and is of greatest significance to metallurgy in America.

In the Moscow Institute of Steel, where Alex is teaching, there is an enrollment of 2000 students in a five-year curriculum. Also there is a substantial enrollment of graduate students.

The faculty numbers about 400 in various fields of science and technology including mathematics, physics, chemistry, and all aspects of ferrous metallurgy. There are some 300 graduates each year. As far as we were able to compare notes on general educational practices, the curriculum is of about the same breadth and depth as the usual metallurgical curriculum in this country. There are six such institutes of ferrous metallurgy in the U.S.S.R., and in addition there are eight schools of technology in which a department of metallurgy is active. Alex is no better than I am about statistics, and he did not claim any sort of accuracy, but he says there are somewhere in the neighborhood of 15,000 people enrolled in these curricula.

When I look at the corresponding figures for the U.S.A., I find that in 1955 there was a total of 2600 men and women enrolled in accredited curricula in metallurgy and that 436 graduated in this subject. In short, his Institute in Moscow alone graduates each year about two thirds as many as all of the accredited metallurgy curricula in the United States! But that is not the whole story. The above Russian figures refer only to the *ferrous* metallurgists. Nonferrous metallurgy is a separate curriculum in Russia and the enrollment is slightly greater than that in ferrous metallurgy. As a very rough figure, Alex thinks there are 20,000 enrolled.

To my query as to what he considered the explanation for such a phenomenal interest in metallurgy, he replied briefly: "The pay is good."


JOHN CHIPMAN, Head
Department of Metallurgy
Massachusetts Institute of Technology
Past-President

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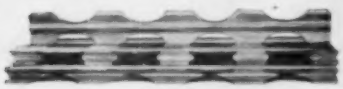

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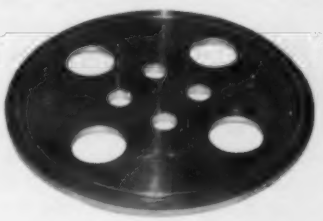

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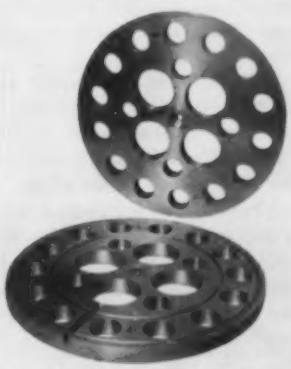

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# Personal Mention

**Van H. Leichliter**

The new president of the American Steel & Wire Div. of United States Steel Corp., Cleveland, is VAN H. LEICHLITER.

Of Dutch descent, Mr. Leichliter was raised in Pennsylvania and received his metallurgical degree from Pennsylvania State College. His career with American Steel & Wire began in 1930 at the Worcester, Mass., South Works where he was employed in the metallurgical laboratory. Four years later he was transferred to the Cleveland office as metallurgist, and in 1935 was named district metallurgist. Rising rapidly in the company, he became assistant superintendent of the Cleveland Newburgh Works and later superintendent of the wire mills at the Cuyahoga Works. During the war years he returned to the Worcester plant and held several superintendent positions until 1950 when he returned to Cleveland. Here he has served as assistant vice-president, operations, and finally vice-president, operations.

In recognition of his achievements in the field of metallurgy, Mr. Leichliter was awarded the David Ford McFarland Award for 1956 by the Penn State Chapter of .

Mr. Leichliter is an active member of the American Society for Metals and American Iron and Steel Institute. In addition, he is vice-president and a director of the American Standards Assoc.

**Thomas G. Digges**

THOMAS G. DIGGES, for 36 years a member of the metallurgy division of the National Bureau of Standards, Washington, D. C., has been named assistant chief of the division.

Educated at Virginia Polytechnic Institute and George Washington University, Mr. Digges joined the N.B.S. staff in 1920 as a scientific aid. Since 1947 he has been chief of the thermal metallurgy section (a post he will continue to hold), in addition to serving as acting assistant chief of the division for the past six years. His work in the division has covered a wide range from studies of the machinability of metals, performance of toolsteels and heat treatment of steels to flow, fracture and ductility of metals at high and low temperatures.

Mr. Digges is especially well known for his research on the use of boron as a substitute for strategic alloys for steel. He received certificates of appreciation from the War Department, the Office of Scientific Research and Development and the Navy Department for this contribution to the defense effort. Further recognition has been awarded him by the Department of Commerce for his "valuable contributions to science and technology".

An active  member, Mr. Digges has served as a national trustee (1950-51), chairman of the Washington chapter  (1945-46), and on the  Publications Committee.

**Paul L. Widener**, senior metallurgist at the Halethorpe, Md., plant of Kaiser Aluminium & Chemical Corp., has been promoted to chief metallurgist at the company's newly acquired plant at Dolton, Ill.

**T. M. Leigh**, formerly development engineer for Link-Belt Speeder Corp., Cedar Rapids, Iowa, is now chief engineer of the newly formed American Hoist Pacific Co., Seattle, Wash., a subsidiary of the American Hoist & Derrick Co., St. Paul, Minn.

**Ray J. Van Thyne**, a specialist in the application of metals to special atomic energy problems, has been named supervisor of reactor metallurgy at Armour Research Foundation of Illinois Institute of Technology, Chicago. Mr. Van Thyne joined the Foundation as an assistant metallurgist in 1950 and was named assistant supervisor of the reactor metallurgy section this year.

**Stephen K. Tarby**, a 1956 graduate of Carnegie Institute of Technology, has been awarded the Jones & Laughlin Fellowship in the department of metallurgy of Carnegie Institute of Technology. This fellowship is part of the Aid to Education Plan recently set up by Jones & Laughlin Steel Corp., Pittsburgh. This plan provides for six university fellowships, six scholarships a year for sons of employees, specific grants to colleges and universities, and the matching of J & L employee contributions to privately supported colleges and universities from which the employee has earned a degree. The J & L Fellowship in metallurgical engineering at Purdue University has been awarded to **Gerard Liedl**. Mr. Liedl, a 1955 graduate of Purdue, has been working toward his Ph.D. degree at the university since his graduation.

**Abraham Smaardyk**  has rejoined Argonne National Laboratory, Lemont, Ill., as an associate mechanical engineer in the reactor engineering division. Mr. Smaardyk was associated with Argonne from 1948 to May 1955, when he left the organization to become associate director of the nuclear engineering department of Edward Valves, Inc., East Chicago, Ind.

4 OF THE MANY STYLES OF THE ONE-PIECE SEAMLESS DOOR KNOBS FABRICATED FROM RUGGED REVERE BRASS STRIP.

# REVERE BRASS STRIP

# Stands the Gaff!

The one-piece door knobs shown are drawn from a single blank of Revere Brass Strip, presenting an attractively smooth, unbroken surface without the need for seams or welds.

Because they are made by a unique procedure the manufacturer tells us that the brass must stand up under mighty rugged going, and that to produce the quality knobs they do, at an economical production level, the brass they use must have:

1. *Uniformity of gauge.*
2. *Absence of any sign of fracture or crimping when drawn.*
3. *Consistently correct grain structure to insure a smooth, flaw-free surface on the finished knobs.*

The manufacturer also tells us that Revere Brass Strip has been filling that bill, with utmost satisfaction, for some time.

Revere Brass Strip may be able to help *you* make a better product at less cost. You'll never know until you talk it over with one of our TA's (Technical Advisor). There's no obligation, of course. And such a discussion could save you a substantial sum of money. Such has been the case many, many times.

COPPER * BRASS 18 01 REVERE * ALUMINUM

**REVERE COPPER AND BRASS INCORPORATED**

*Founded by Paul Revere in 1801*

230 Park Avenue, New York 17, N. Y.

*Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.*

ACCO products

# Wilson "Rockwell"* Hardness Testers

## Is HARDNESS an important factor in your business?

• If your business involves metals, successful operation often requires *exact* knowledge of the proper hardness of the materials you make or work with.

**In heat treating departments** ▶
WILSON "ROCKWELL" testing of hardened and tempered steels is universal.

**In metallurgical laboratories**
They provide means for establishing thousands of hardness specifications.

**In the tool room**
They are relied upon for absolute guidance as to the hardness of tools and the metals to which they are applied.

◀ **In the inspection department**
Inspection of parts to see that they actually meet specifications is an important use of WILSON "ROCKWELL" hardness testers. On the inspection line they help insure the quality of the product, reduce defects, and retain the good name and reputation of the manufacturer.

**In the production department** ▶
WILSON "ROCKWELL" hardness testers are ideal for use in production testing. The test, complete from work insertion, loading procedure, feeding, removal of work piece—is a matter of three to five seconds depending on the skill and dexterity of the operator.

• For complete information on "WILSON ROCKWELL" Hardness Testers call or write today. There is a WILSON model to meet every testing requirement.
*Trademark registered

WILSON "ROCKWELL"
the world's standard of hardness accuracy

ACCO Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE
230-F Park Avenue, New York 17, N. Y.

for Better Value

## Personals . . .

**Orville T. Barnett** and **John Rudy**, both affiliated with the Armour Research Foundation of Illinois Institute of Technology, received the $1000 Fifth Award in the recent competition for ideas to accelerate the progress of arc welding, sponsored by the Jame F. Lincoln Arc Welding Foundation, Cleveland, Ohio. This award was one of 20, totaling $20,000, made to men in 16 different states.

**Charles E. Clinton** has joined the atomic power research laboratory of the Bettis Plant, Westinghouse Electric Corp., Pittsburgh. His duties will include engineering development work on nuclear cores.

**Robert L. Stephenson**, formerly associated with the University of Kentucky, has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

**George A. Uhlmeyer**, director of area development for the Iowa-Illinois Gas & Electric Corp., Rock Island, Ill., has been appointed general manager and chief administrative officer in charge of United States operations for Cochshutt Farm Equipment Co., Bellevue, Ohio. In his new position, Mr. Uhlmeyer will be responsible for the firm's manufacturing, distribution and sales operations throughout the country. Headquarters of the company are in Brantford, Canada.

**Clayton O. Matthews** is now in charge of the nuclear materials program at the new Lockheed Aircraft Corp.'s missile systems research laboratory at Palo Alto, Calif. He was previously a research metallurgist at the Los Alamos Scientific Laboratory, Los Alamos, N.M.

**William E. Cranor** has been appointed Canadian sales representative by A-B-C Packaging Machine Corp., Tarpon Springs, Fla., and International Filling Machine Corp., Petersburg, Va., and will organize their sales development programs across Canada. Mr. Cranor is also president of National Cutlery, Ltd., Toronto, Ont., and was associated with Canners' Machinery, Ltd., Simcoe, Ont., for several years, recently serving as district sales manager in Toronto.

# New LINDBERG–FISHER Autoladle

We call it "LITTLE JOE"

Here, for the first time, is a ladling unit that makes automatic casting of aluminum not only possible but practical. The Autoladle has been thoroughly tested and proven in service.

**"LITTLE JOE"** provides these advantages:

- Adaptable to induction, electric resistance or fuel-fired reverberatory furnaces.
- Ladled metal is withdrawn from beneath surface of bath.
- Precise, accurate control of any size shot up to 30 lbs.
- No interruption of the casting cycle during charging of metal.
- No variation of size of shot due to metal level changes.
- Composed of special refractory materials so arranged that ladled metal cannot come in contact with any metal.

To the best of our knowledge this is the first practical automatic ladling unit yet devised. It will fill an important need in many casting operations. For complete information, get in touch with your nearest Lindberg Field Representative (see your classified phone book) or write direct.

**LINDBERG FISHER MELTING FURNACES**

**A Division of Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois**

# Cambridge

## WOVEN WIRE CONVEYOR BELTS take the bottlenecks out of HEAT TREATING

HEATPROOF—RUSTPROOF, all-metal belt provides controlled movement for continuous heating, cooling, washing.

By combining movement with processing, Cambridge Woven Wire Conveyor Belts completely eliminate profit-stealing batch handling. Continuous, belt-to-belt flow through annealing and tempering furnaces, quenching and pickling baths, and wash sprays cuts costs and provides continuous uniform production.

All-metal belt is corrosion resistant and impervious to heat damage at temperatures up to 2100°F. Open mesh construction allows heat and gases to circulate freely all around the work and provides rapid drainage of process solutions. Cambridge belts have no seams, lacers or fasteners to wear more rapidly than the body of the belt . . . no localized weakening. Cambridge Woven Wire Belts for heat treating are made in any size, mesh or weave, and from any metal or alloy. Special retaining edges or cross-mounted flights are available to hold your product during inclined movement.

**Call in your CAMBRIDGE FIELD ENGINEER to discuss how you can eliminate batch handling from your heat treating. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for your copy of Special Report, "6 Ways to Increase Heat Treating Production" and 130-PAGE REFERENCE MANUAL giving mesh specifications, design information, metallurgical data.**

**The Cambridge Wire Cloth Company**

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department B
Cambridge 1, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

## Personals . . .

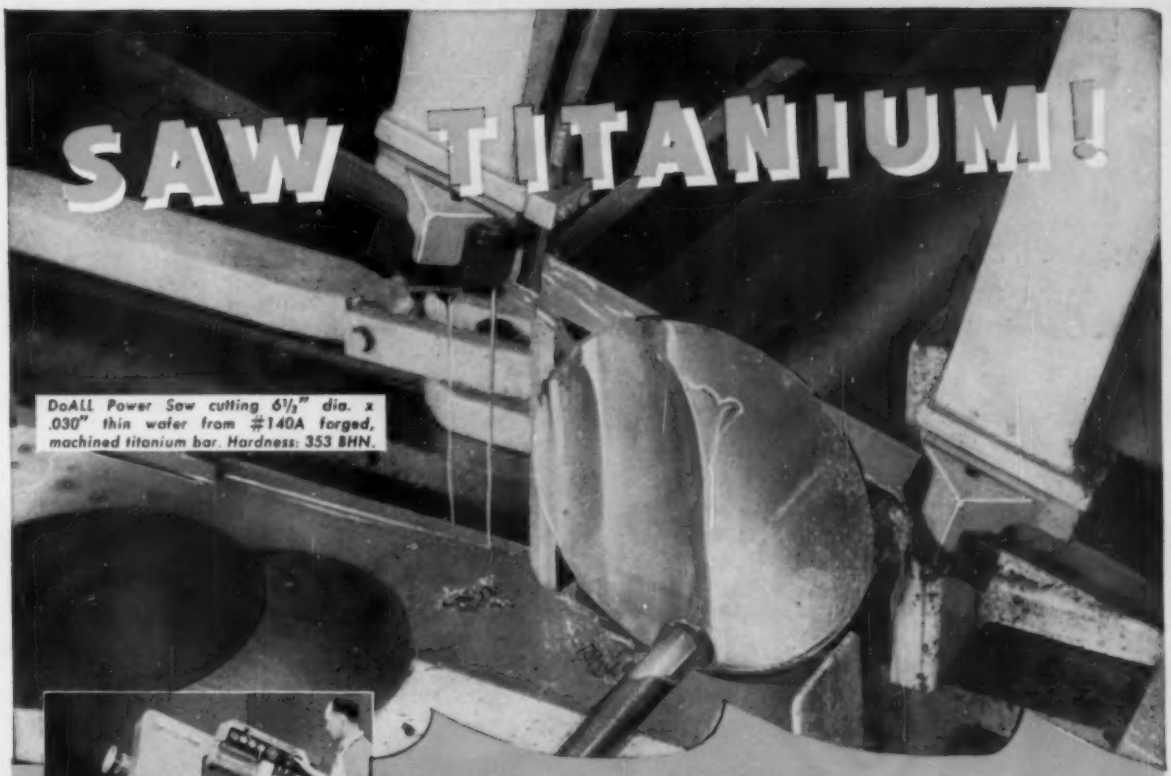
**Hugh F. Beeghly** was recently named research associate for Jones & Laughlin Steel Corp., Pittsburgh. In his new position, Mr. Beeghly assumes the responsibility for applying developments in the nuclear energy field to the processes of the steel corporation and for recommending application of present J&L products or the development of new products for nuclear purposes. He will also act as consultant on new analytical techniques and on research programs. A member of J&L's research division since 1938, he last held the position of section head, chemistry, in the research and development department.

**Kenneth W. Donle** has been promoted to the position of manager of product engineering at the Tube Reducing Corp., Wallington, N.J. He will also be responsible for new product development. Associated with the company since 1951, Mr. Donle has served as chief metallurgist and more recently manager of the Rockdrawn Tubing Div. of Tube Reducing Corp.

**Malcolm F. Judkins**, manager of new products division, Firth Sterling Inc., Pittsburgh, attended the British Nuclear Power Conference in London last November. Mr. Judkins also presented the feature lecture on nuclear reactor materials at the Belgian Nuclear Power Conference held a week later in Brussels. In addition, he visited Germany, France, Switzerland and Italy and conferred with the organizations which are engaged in designing and constructing nuclear power reactors.

**J. D. Campbell** has been elected vice-president and a director of the newly established American Lithium Institute, Inc., a nonprofit organization for the purpose of conducting research on lithium and its compounds. The Institute will also act as an agency for the correlation and dissemination of technical information on lithium. It was formed by the three major lithium producers in the United States, American Potash and Chemical Corp., Foote Mineral Co. and Lithium Corp. of America. Mr. Campbell is associated with the latter organization.

# SAW TITANIUM!



DoALL Power Saw cutting 6½" dia. x .030" thin wafer from #140A forged, machined titanium bar. Hardness: 353 BHN.

**the Machine: DoALL**
**the Blade: Demon HSS**
**the Answer: Rigidity and Power**

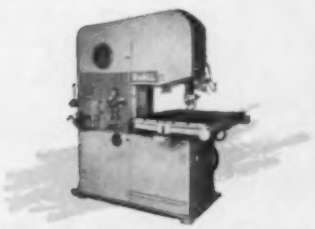
You can saw titanium—rapidly, accurately and economically—in spite of its extreme toughness and many inconsistencies.

*It takes a rigid, powerful saw.* The versatile, new DoALL Power Saws and Contour-matic band machines transmit positive *controllable* power, through infinitely variable speed drive and constant automatic, hydraulic power feed. Frames are rigid, rugged . . . built to deliver fast, accurate cuts for every bit of power consumed.

*It takes High Speed Steel Saw Bands.* DoALL *Demon* HSS Saw Bands have proven best for sawing titanium and other tough-to-cut alloys. They're built to retain their tooth hardness at temperatures up to 1100°F which means that they can be run much faster and thereby cut faster.

*It takes Know-How.* DoALL can help here, too. Submit a sawing sample and state your problem. DoALL customer research laboratory will conduct sawing tests with standard machines under shop conditions. Detailed report will provide recommendations on machine, speed, feed, saw type, coolant, production rate, tool life, etc. Call your local DoALL Sales-Service Store for details or write:

**LAB SERVICE**
. . . and Helpful Data. Write for specific sawing data on titanium or other materials in which you are interested.



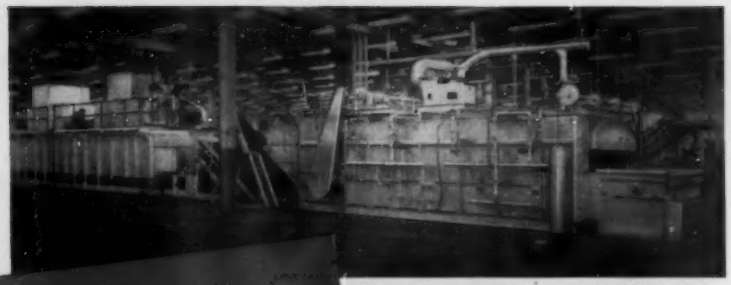
The DoALL Contour-matic machines a greater variety of materials more efficiently than any other machine tool.

DoALL

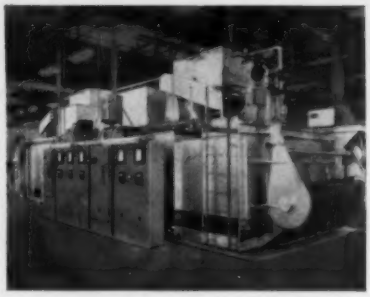
**THE DoALL COMPANY**
DES PLAINES, ILL.

PBM-36

**LOCAL SERVICE**—38 DoALL Sales-Service Stores provide prompt, competent attention to your sawing needs through *factory trained* personnel.



# ...in Automated Harden Quench and Draw



A large automotive plant required furnaces to heat treat 4,000 lbs. per hour of forgings or castings automatically. The equipment had to be durable to produce a constant uninterrupted flow of parts and also effect a substantial saving over previous methods.

Industrial's direct fired continuous belt type hardening furnace and famous "CIRC-AIR" draw are doing the job. Loading 35 lbs. per square foot of conveyor, hardening is at 1700 deg. F., quench in 1700 gallons of oil and temper at 1200 deg. F.

The rugged, dependable Industrial furnaces are completely automatic; produce 4,000 lbs. per hour every hour every day.

Besides saving man hours, there is a 20% fuel saving by use of the continuous belt conveyor operating wholly within the hardening furnace.

Industrial's "CIRC-AIR" draw furnace is the most efficient heating machine made for temperatures up to 1300 deg. F. High velocity fans force recirculated hot gases through the work with no temperature head. Thin and thick sections come to heat evenly; and the entire load is heated uniformly.

*Send for "CIRC-AIR" Bulletin No. 13-A*

CIRC-AIR

INDUSTRIAL
HEATING EQUIPMENT CO.

3570 FREMONT PLACE, DETROIT 7, MICHIGAN • WALNUT 3-7000

PIONEERS AND STILL LEADERS IN RECIRCULATION


## Personals . . .

**Charles M. Hawkins** is the new general manager of Ehrhardt Tool & Machine Co., St. Louis, Mo. Since joining the company as an apprentice in 1940, Mr. Hawkins has served in various capacities including sales engineer and more recently plant manager.

**Edward Hartshorne** has accepted the post of general manager of the Nuclear Fuel Div., Olin Mathieson Chemical Corp., New Haven, Conn. Affiliated with Olin since 1934, Mr. Hartshorne most recently served as executive vice-president and a member of the board of directors of Bradley Container Corp., Maynard, Mass., formerly a subsidiary of Olin Mathieson. Prior to that, he was manager of the research and development department of the film division of the corporation.

**Harry E. Orr** has been named to the newly created position of commercial vice-president in charge of engineering sales for the Vanadium Corp. of America, New York. Prior to this appointment, Mr. Orr was assistant vice-president and manager of engineering sales with headquarters in Vanadium's Chicago district offices. He will now be located in the Pittsburgh district office.

**Clive C. Earle** has been promoted to manager of alloy and stainless steel sales at the Pittsburgh plant of Joseph T. Ryerson & Son, Inc. Joining Ryerson at its Buffalo plant in 1944, Mr. Earle became a member of the alloy and stainless steel department and three years later was appointed a sales representative for the department. He remained in this position until his promotion.

**Edward F. Sixtus, Jr.,** has resigned from General Metals Corp., Oakland, Calif., to take a position with Industrial Siderurgica, Inc., San Juan, Puerto Rico.

**Howard H. Wilder**, formerly assistant manager of engineering sales, Vanadium Corp. of America, New York, has been promoted to manager of engineering sales. Mr. Wilder will have his headquarters in the company's Chicago office. Until recently he was at Vanadium's Detroit office as manager of the iron foundry division.

To Keep Your Product Quality High, Specify

## YOUNGSTOWN SHEETS AND STRIP

This modern production line is busy turning out high quality steel stampings for electric range tops. To help maintain their excellent reputation for quality work, this progressive concern relys on Youngstown Sheets and Strip—the best drawing and stamping steel obtainable anywhere.

Youngstown's half-century of steelmaking know-how guarantees you a blend of the right combination of tensile strength, surface finish and ductility to provide top-production runs of even the most difficult-to-form work.

Satisfied users tell us they get increased production, fewer rejects, faster and more accurate forming, together with lower fabrication and die costs. Why not get the same advantages by making Youngstown Sheets and Strip your specification? They are quality-controlled through every steelworking, rolling and annealing operations to meet your most exacting requirements.

Contact our nearest District Office, today, for additional information or metallurgical assistance—or write directly to our Home Office.

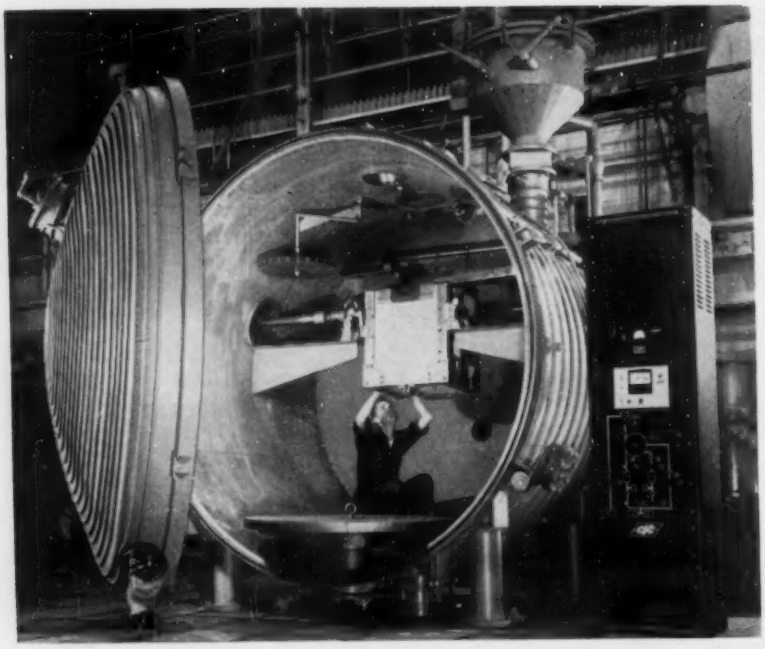
QUALITY YOUNGSTOWN SERVICE

**COLD ROLLED SHEETS AND STRIP**

THE Youngstown SHEET AND TUBE COMPANY

General Offices - Youngstown 1, Ohio
District Sales Offices in Principal Cities

*Producers of Quality Carbon and Alloy Steels for Over Half-a-Century*



CEC's new 300 to 1000 pound vacuum induction melting furnace.

## Get a vacuum furnace that *grows* with your needs

Save costly alterations, or the purchase of another furnace, when your requirements change. Make sure you get these features:

**Flexible capacity.** Expand the furnace's basic 300-pound capacity to as much as 1000 pounds simply by changing the crucible-coil.

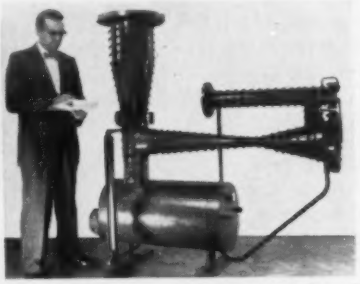
Add an interlock valve to the charging assembly and process as much as 3000 pounds of metal without breaking vacuum.

**Flexible pumping system.** Add a pump, or switch to larger pumps, and double, triple, even quadruple the pumping system's speed and capacity.

**Flexible casting.** Cast a single large mold or many small ones; add such accessories as arc hot-topping equipment in ports already provided.

**Flexible accessories.** All necessary accommodations for a sampler, immersion thermocouple, optical sight tube, vacuum throttling valve, interlock valve for charge addition, or any other accessories you want to add.

For more details on this flexible CEC induction melting furnace send for Bulletin 4-35.



Pumping systems are interchangeable: 1 or 2 KS-2000 (shown here), 1 or 2 KS-4000, or one KS-16,000.

CEC

**Consolidated Electrodynamics**

**Rochester Division, Rochester 3, N. Y.**

*formerly Consolidated Vacuum*

NATIONWIDE COMPANY-OWNED SALES AND SERVICE OFFICES


## Personals . . .

**W. D. Bennett** has been added to the new General Atomic Div. of Canadair Limited, Montreal, Quebec, Canada, as acting chief of the development section. Dr. Bennett was previously affiliated with Atomic Energy of Canada, Ltd., and the Canadian Dept. of Mines.

**Robert J. Rohr** has joined the Magnus Chemical Co., Inc., Garwood, N.J., as midwest regional sales manager, responsible for the administration of sales and service activities in the midwest. Dr. Rohr has spent many years in the sales and service of chemicals and equipment both in this country and in Europe.

**Peter E. Rentschler**, president of the Hamilton Foundry & Machine Co., Hamilton, Ohio, was the recipient of the Gray Iron Founders' Society Gold Medal, the association's highest award, at the annual meeting of the Society last fall. Mr. Rentschler was honored for leadership in progressive foundry management with particular reference to good housekeeping and safety practices, and improved industrial and public relations. He has held various executive positions with the Society, including president, director, and chairman of the Terms and Conditions of Sale Committee.

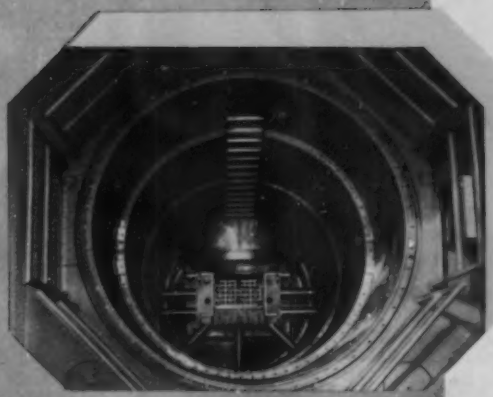
**Joseph F. Nachman**, until recently chief of the metallurgy branch of the magnetics division, Naval Ordnance Laboratory, Silver Spring, Md., has been added to the alloy department of the Denver Research Institute at the University of Denver, Col. **Richard Beck**, more recently with the Rocky Flats plant of Dow Chemical Co., Denver, will work in the alloy department on the influence of interstitials of titanium alloys for the Institute.

**Roger J. Metzler**, formerly assistant manager, engineering division, Handy & Harman, New York, is now sales manager of WaiMet Alloys Co., Detroit.

**George M. Pyle, Jr.,** has joined the atomic power research laboratory at the Bettis Plant, Westinghouse Electric Corp., Pittsburgh. Mr. Pyle's duties will consist of enginnering development work for nuclear cores.

*another example of exciting work at los alamos...*

# OMEGA WEST



Omega West, newest of the research reactors at Omega site in Los Alamos, is one of several reactors in operation or under development at the Laboratory. The OWR is designed for high flux at low cost, flexible operation, and has extremely versatile port facilities. This installation is an important addition to the impressive array of research facilities available to Los Alamos scientists.

The Laboratory is interested in receiving employment applications from engineers and scientists of superior qualifications. Direct your inquiry to:

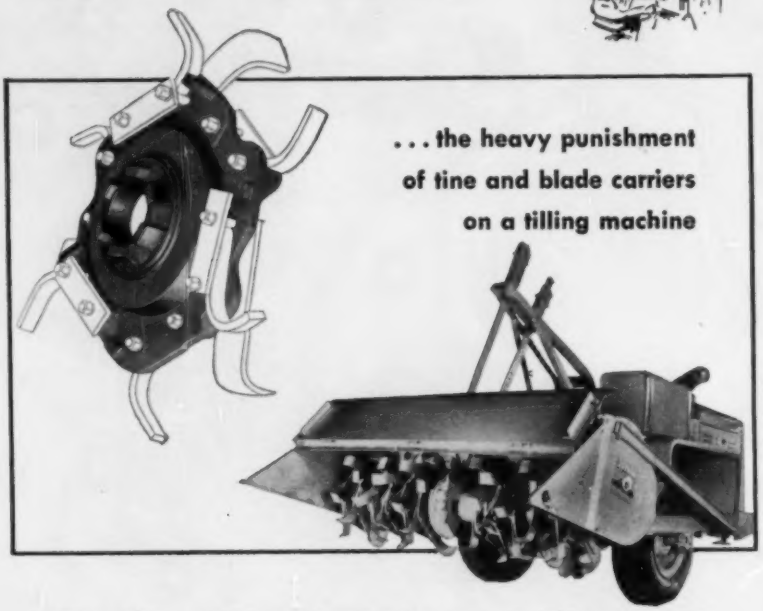
Department of Scientific Personnel
Division 1617

*Los Alamos Scientific Laboratory is a non-civil service operation of the University of California for the U. S. Atomic Energy Commission.*

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

# How about Malleable?

## It's the solution to many problems like this one



. . . the heavy punishment of tine and blade carriers on a tilling machine

The ability to take *tough going* has to be built into any soil working equipment. Malleable Iron plays an important part throughout the industry because toughness is its middle name!

In the Seaman Tiller shown above, over 1000 pounds of Malleable castings are used in each machine—in the carriers, transmission cases, torque tube brackets and other heavy-duty parts.

"Whether tilling heavy soil in California or stony fields in New England, our tillers with their tough malleable carriers stand up in service"—is the way Seaman Motors, Inc. of Milwaukee expresses it.

That describes the *end* result. Of equal interest to the *manufacturer* are the many processing and cost advantages that Malleable Iron has to offer. It will pay you to consult your nearest malleable foundry, or write to this Society for information.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio


## Personals . . .

**Charles F. Walton**, technical director of the Gray Iron Founders' Society, Inc., was re-appointed for another year at the annual meeting of the Society in Hot Springs, Va. last fall.

**Kenneth E. Fritz** has been named to the metallurgy unit of the materials and processes laboratory, large steam turbine-generator department, General Electric Co., Schenectady, N.Y., and will work in the field of turbine and generator forging alloy development. Before coming to General Electric in 1955, Mr. Fritz was employed by the Naval Research Laboratory, Washington, D.C., and the Bucyrus-Erie Co., Milwaukee, Wis.

**Bernard P. Planner** has become a member of the European operations staff of Armour Research Foundation of Illinois Institute of Technology, Chicago. Dr. Planner will be one of a number of observers for the European Technological Observation Group recently established by the Foundation to keep American companies abreast of European technological developments. His post will be that of metallurgical observer with headquarters at The Hague, Netherlands. A native of Austria, Dr. Planner studied and worked in Germany until the outbreak of World War II when he came to the United States. His last position was senior development engineer with Marquardt Aircraft Co., Van Nuys, Calif.

**John P. Nielsen**, chairman of the department of metallurgical engineering, College of Engineering, New York University, recently spent a month in the U.S.S.R. as a guest of the Soviet Academy of Sciences. Dr. Nielsen was invited to visit Russia by the deputy director of the Institute of Metallurgy in Moscow, A. M. Samarin, who attended the one-week special course on titanium metallurgy held at the N.Y.U. College of Engineering early last fall. During his visit, Nielsen lectured at the Institute of Metallurgy, attended a conference on atomic energy in Moscow, and visited metals institutes and plants in other parts of the country.

# HOW SINGER GETS NEEDLE-FINE CONTROL OF CASE DEPTH WITH AEROCARB® E+W CARBURIZING COMPOUNDS

The Singer Manufacturing Company, Elizabethport, N. J., finds that AEROCARB E and W Carburizing Baths make it easy to control case depths of their sewing machine parts within thousandths of an inch, producing excellent wear resistance.

Vertical operating presser bar shafts and needle bar shafts for their 99 Class Sewing Machines are case-hardened at 1650°F. SINGER gets fast penetration with minimum distortion, and finds water-soluble AEROCARB E & W easy to remove. Parts emerge from the carburizing operation bright, clean and straight, ready for fast and easy finishing.

AEROCARB E & W can help you, too, get exactly the desired case composition and case depth with low distortion. For specific information on the use of Cyanamid's AEROCARB Carburizing Compounds, mail us the coupon.

**CYANAMID'S HEAT TREATING COMPOUNDS INCLUDE:**

AEROCASE® Case Hardening Compounds
AEROCARB® Carburizing Compounds
AEROHEAT® Heat Treating Compounds
AEROMET® Metallurgical Additive
Metallic Stearates
Surface Active Agents
Acids and other Heavy Chemicals

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Send Technical Data Sheet on AEROCARB E & W Carburizing Compounds.

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Company.....

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DURALOY
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HIGH ALLOY CASTINGS
FOR HIGH TEMPERATURE
SERVICE

1700°F

*Here's an Annealing Retort*
*for 1700° F Service*
*35% Ni—15% Cr*
*30" Diameter 30' Long*

Duraloy is the place to come for high alloy castings—for high temperature service, for highly corrosive service. Castings to your specifications are a Duraloy specialty.

We are equipped to do large and small work. We can turn out single static castings of 7 tons or more and single centrifugal castings up to about 4½ tons. On your next high alloy casting job, check with Duraloy!

***Send for Bulletin No. 3354-G***

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EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
DETROIT OFFICE: 23908 Woodward Avenue, Pleasant Ridge, Mich.
CHICAGO OFFICE: 332 South Michigan Avenue

## Personals . . .

**Francis E. Adams** has transferred from the Atomics International Div., North American Aviation, Canoga Park, Calif., to the Columbus, Ohio, division of North American and is engaged in development work in welding and brazing of high temperature materials.

**W. G. Brown** has been promoted to general superintendent of the Seymour Mfg. Co., Seymour, Conn. Mr. Brown, who was acting casting shop director and assistant general manager at the time of his promotion, has been with Seymour for a year.

**E. J. Ripling** was recently named laboratory director of mechanical metallurgy at Continental Can Co.'s new central research and engineering division. Dr. Ripling formerly directed research projects on magnesium and titanium as an assistant professor of metallurgy at Case Institute of Technology.

**Howard R. Spendelow, Jr.,** until recently assistant director of research of the Metals Research Laboratories, Electro Metallurgical Co., a division of Union Carbide & Carbon Corp., Niagara Falls, N.Y., is now manager, patents and licenses, for the company. In addition to his work with patents and licenses, Dr. Spendelow will serve in a liaison capacity between Electromet's research, development, engineering and production departments and Union Carbide's patent department.

**Hyman Rosenthal** has been appointed director of research for Arwood Precision Casting Corp., New York. Since 1939, Mr. Rosenthal had been associated with the U.S. Army Ordnance Corps' Metallurgy Research Laboratory at the Frankford Arsenal, Philadelphia. In 1943 he organized the Laboratory's research division and served as its head for 11 years. Mr. Rosenthal's last position was that of deputy director of the entire laboratory.

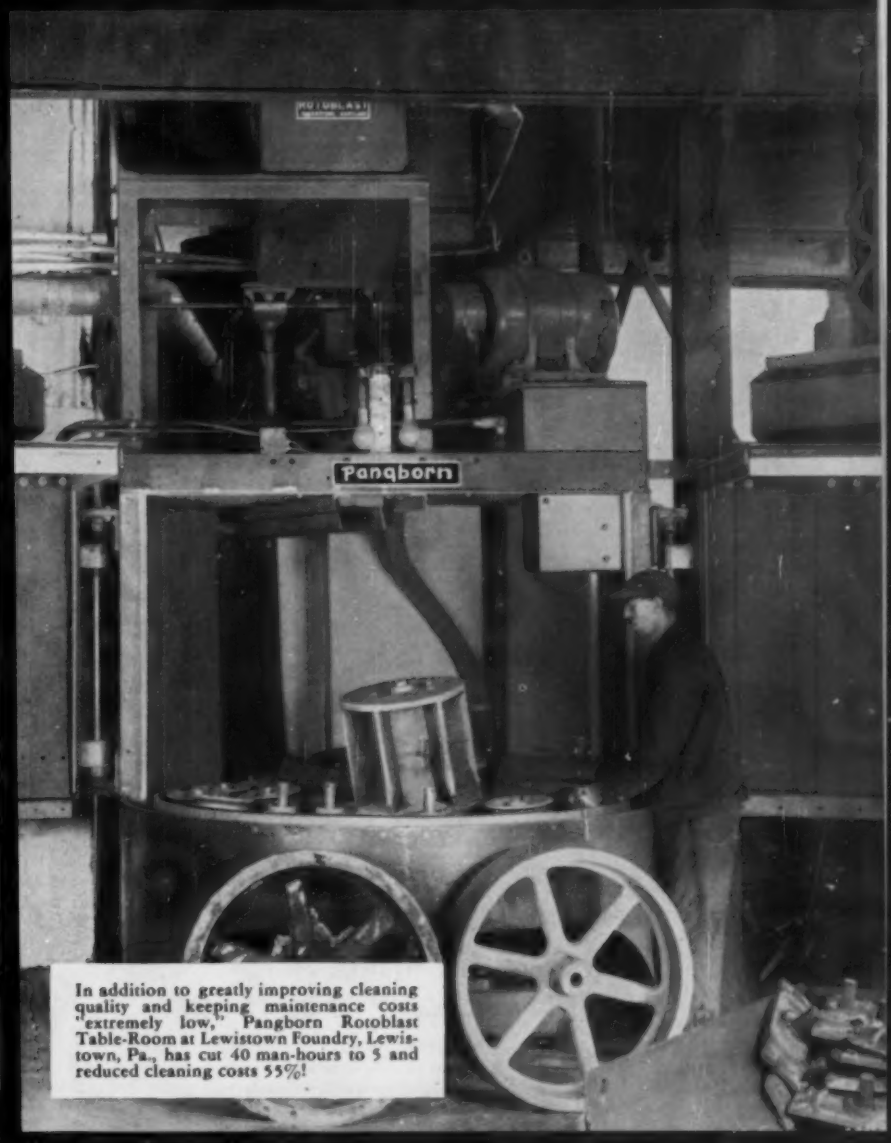
**Donald H. Desy** has joined the staff of Fulmer Research Institute, Stoke Poges, Buckinghamshire, England. Mr. Désy recently received the degree of Doctor of Engineering Science in Metallurgy from Columbia University, New York.

# Pangborn Rotoblast® reduces cleaning costs 55% at Lewistown Foundry!

One foundry says it "cuts labor costs." Another says it "reduces maintenance." A third says, "speeds production." Foundries that blast clean with Pangborn Rotoblast equipment can offer different reasons —and combinations of them—for Rotoblast's cost-cutting operation.

They all add up to one thing—*lowest cost per ton of castings cleaned!* That's because Pangborn Rotoblast cleans thoroughly, quickly, automatically. You get a finer, uniform finish on your jobs; power and labor costs go down; maintenance costs drop; production goes up.

Check your present cost per ton and then find out how Pangborn can *slash* your cleaning costs. Write for Bulletin 227 to PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*




In addition to greatly improving cleaning quality and keeping maintenance costs "extremely low," Pangborn Rotoblast Table-Room at Lewistown Foundry, Lewistown, Pa., has cut 40 man-hours to 5 and reduced cleaning costs 55%!

## And cuts labor costs in half at Keen!

Pangborn Rotoblast Table and Rotoblast Barrel at Keen Foundry, Griffith, Ind., clean *three times faster* than previous equipment, cut cleaning room labor costs 50%!

# Pangborn

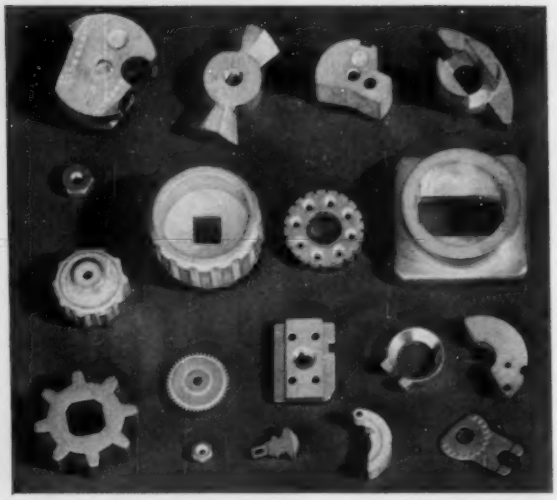
## BLAST CLEANS CHEAPER

Rotoblast Blastmaster® & Continuous-Flo® Barrel | Rotoblast® Tables & Table-Rooms | Special Blast Rooms & Cabinets | Pangborn Dust Control Equipment

Distributors for Malleabrasive and Tru-Steel Abrasives

# MEETING DESIGN NEEDS

## *Even greater savings in product costs are possible with* BRASS AND NICKEL SILVER POWDERED METAL PARTS

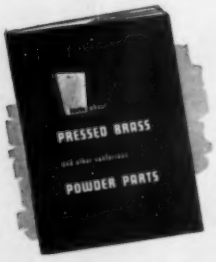


Very substantial savings are being realized by manufacturers who have turned to powder metallurgy for structural and functional parts. In each case, use of the metal powder process was justified by cost comparison with a previous method of meeting design needs.

Even greater economies could have been achieved by these manufacturers if sinterings had been used initially. Immediate savings over other possible methods are much greater when the high cost of original tooling and the cost of conversion can be avoided.

When designing a new product, first investigate the use of BRASS AND OTHER NONFERROUS POWDER PARTS. Consult a Powdered Metal Fabricator and take advantage of his experience in cost-saving production methods.

## How Can BRASS AND NICKEL SILVER POWDER PARTS Meet Your Design Needs?




For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of your particular needs.

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THE NEW JERSEY ZINC COMPANY
160 Front Street New York 38, N. Y.


## Personals . . .

**W. W. Sellers** has transferred to the new Glasgow, Scotland, plant of Caterpillar Tractor Co. as quality control manager for a three to four year period. Caterpillar is constructing a new manufacturing plant in Glasgow which will go into opertion in early 1958. Mr. Sellers formerly was located at the home office of Caterpillar in Peoria, Ill.

**Charles R. Wilks**, a metallurgist at the research center of American Brake Shoe Co., Mahwah, N.J., for 14 years, has joined Glenn L. Martin Co., Baltimore, Md., as group engineer, materials engineering and development. Mr. Wilks will supervise the new metals group and evaluate and appraise new metals and alloys for aircraft use.

**L. F. Kendall**, formerly with the General Electric Co.'s Hanford Atomic Products Operation, Richland, Wash., has transferred to the nuclear materials in general engineering laboratory, General Electric Co., Schenectady, N.Y.

**Thomas C. Fetherston**, assistant director of public relations for Union Carbide and Carbon Corp., New York, has been elected president of the New York State School Boards Assoc., Inc., at the association's annual meeting in Syracuse, N.Y. Mr. Fetherston is president of the Board of Education of Oceanside, N.Y., and has also held several executive positions with the New York State School Boards Assoc. prior to his election as president.

**A. Hurlich** has left his position as chief of the materials engineering laboratory, Watertown Arsenal, Watertown, Mass., to become head of the materials research and development section, Convair-Astronautics Div., General Dynamics Corp., San Diego, Calif.

**Alexander Yorgiadis**, formerly connected with the Sandia Corp., Albuquerque, N.M., is now chief development engineer with the Ivy Co., Norwalk Conn.

**C. Dale Dickinson**, a recent recipient of a doctorate degree from the University of Michigan, is now a research engineer at the Mallory-Sharon Titanium Corp., Niles, Ohio.

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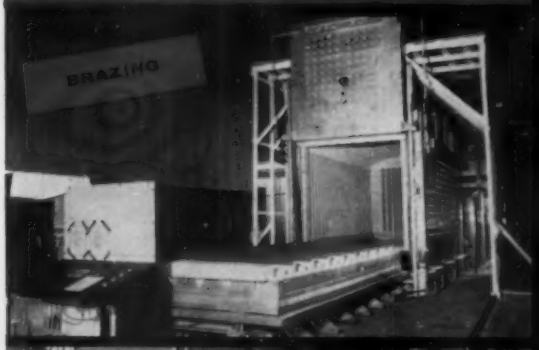

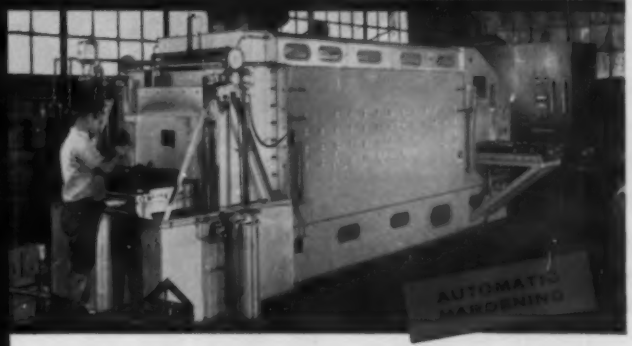

Whether it's *versatility* you need—a single furnace that can handle any number of different heat treating jobs efficiently—or a *specialized* piece of equipment to do a single job to super-critical tolerances—Pacific's complete line gives you *exactly* the right one for your job!

The installations shown here are just a few of Pacific's "standard" furnace designs. In addition, modifications or completely custom designed furnaces can be built to your own specifications. A Pacific field engineer will be glad to discuss your heat treating problems or requirements—write today!

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## FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

*Engineered*

**FURNACE RETORTS**

*that* SERVE BETTER
LAST LONGER
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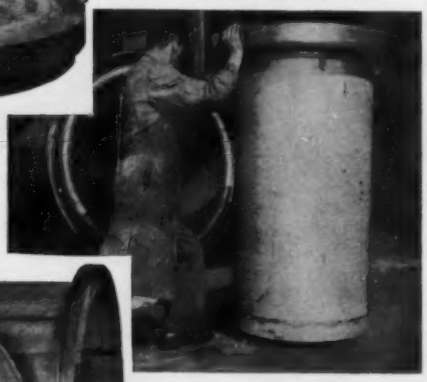
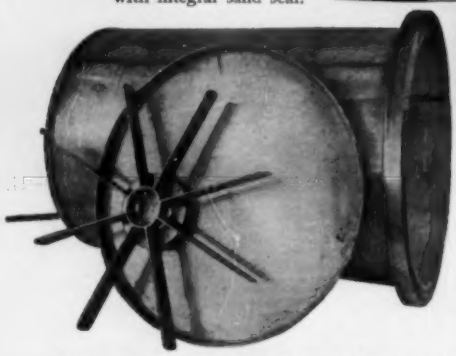
*per furnace hour*

Stainless steel hoods for bell-type bright annealing furnaces. 77" O.D. x 88" high.



A special and very successful Rolock design with integral sand seal.



A special design built within a few days without costly patterns.

Here are three of the important furnace retort designs currently fabricated by Rolock specialists . . . each making an impressive record of excellent, low-cost service. Essential features include experienced design and construction engineering . . . unique Rolock know-how and experience in fabricating modern high-heat-resistant wrought alloys . . . quality standards maintained and safeguarded by detailed X-ray and other forms of inspection. Write for our new comprehensive catalog, or send your prints for quotation.

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Easier Operation, Lower Cost

8RL56


## Personals . . .

**E. R. McKinstry** has been transferred from the Pittsburgh office of Pittsburgh Steel Co. to the Dayton, Ohio, plant as a metallurgist.

**John T. Stacy**, until recently associated with Battelle Memorial Institute, Columbus, Ohio, has accepted a position with the structural staff, metals unit, Boeing Airplane Co., Seattle, Wash.

**Joseph Neri, Jr.,** is now an engineer in the materials section of the nuclear division of Glenn L. Martin Co., Baltimore, Md. Prior to this appointment, Mr. Neri was with the Ames Laboratory, Ames, Iowa.

**D. S. Bowman** has been selected for the position of assistant sales manager for the Globar Div., Carborundum Co., Niagara Falls, N.Y. Mr. Bowman has spent six years in the Chicago district and two years in the Pacific district of the company as field sales engineer.

**T. C. Du Mond** has been appointed to develop a department specializing in metalworking and engineering materials accounts for Harry W. Smith, Inc., New York, technical publicists. Prior to joining the Smith organization, Mr. Du Mond served as editor of *Materials & Methods* magazine for ten years, and before that was an associate editor of *American Machinist*.

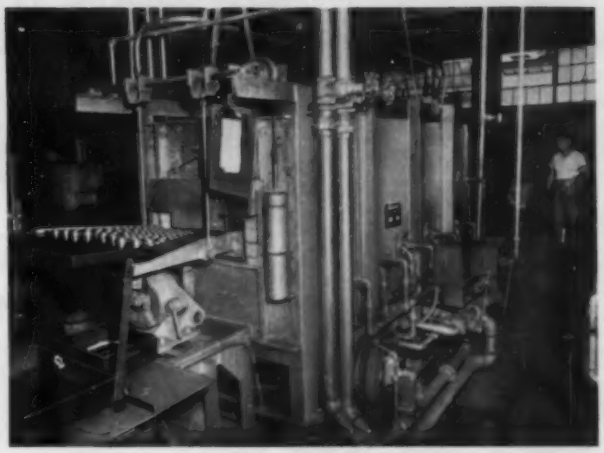
**Emil G. Holmberg** has been transferred to the Detroit technical section of the development and research division of the International Nickel Co., New York.

**Walter H. Wiewel**, senior vice-president of Crucible Steel Co. of America, Pittsburgh, will direct the operation of the new Crucible Division, Vacuum Metals Corp., Cambridge, Mass. Vacuum Metals, originally organized by the National Research Corp., has operated as a jointly owned company since 1954 when Crucible purchased a 50% interest in the company. Crucible recently acquired the entire interests of National Research to make Vacuum Metals a wholly-owned subsidiary. **James H. Moore** will continue as general manager of Vacuum Metals Corp.

# THREE New cost-reducing Sunbeam FURNACES

## 1 LOW MAINTENANCE COST

**SUNBEAM RECIPROCATING HEARTH FURNACE** used to heat treat bearing parts. This nationally known manufacturer added a second unit to increase production after 15 years of low maintenance costs on a similar Sunbeam installation. View to the right shows the underfired design featuring Sunbeam Stewart nozzle mixing burners to assure uniform heating and prevention of flame impingement on the work.



## 2 HIGH PRODUCTION

**SUNBEAM GALVANIZING SETTING** used for processing a wide variety of work up to 13 feet long and 550 pounds. Settings of this type assure low dross, high production and long kettle life. Automatic temperature control in either one or two zones is standard practice.

## 3 REDUCED COSTS

**SUNBEAM HEAVY PORTABLE OVEN FURNACE** used to heat treat railroad car and locomotive springs, bolts and track tools. Manufacturing costs have been greatly reduced due to the almost complete elimination of surface decarburization and rapid heat up time.

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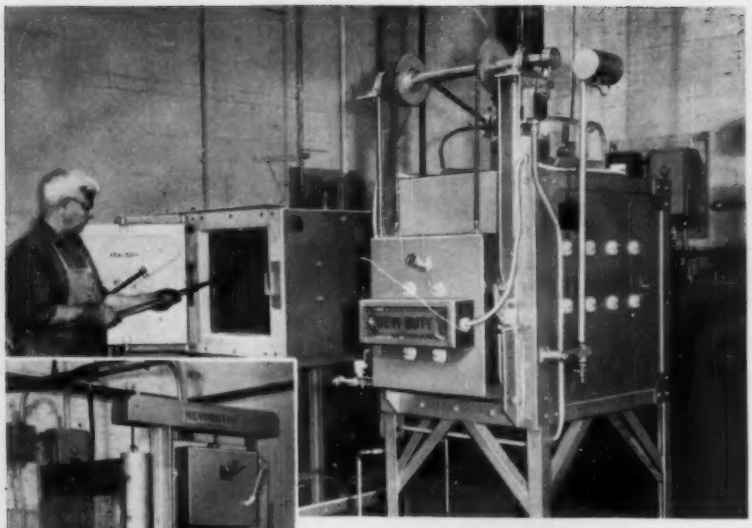

HEVI-DUTY Tool Room Combination provides *"More Versatility... Greater Uniformity"* at **argus cameras.**

Argus uses these Hevi-Duty Furnaces for all heat treating operations on their tools, dies, gauges, and castings. Carl Bates, Tool Room Foreman, reports, "These furnaces provide uniformly good results on all operations, high temperature and low. We have used them for hardening, tempering, drawing, normalizing, and pack carburizing and have found them completely dependable."

*The Argus Tool Room Combination consists of:—*

1. Hevi-Duty Multi-Range Box Furnace, used for hardening, drawing, normalizing and pack carburizing. A high speed fan combines with five sided heat to provide even temperatures to 1800° F. throughout the work chamber.
2. Hevi-Duty "Hi-Treet" Globar Furnace, used for hardening high speed steel at temperatures up to 2500° F.
3. Hevi-Duty "Temperite" Box Air Draw Furnace, used for low temperature drawing and tempering. High speed fan and baffle assures uniform distribution of heat throughout the furnace chamber.
4. Hevi-Duty Endothermic Generator provides a controlled atmosphere keeping the high speed steel from oxidizing and decarburizing.

These furnaces combine to give the best in both high and low temperature operations. If you want to discover how to modernize your tool room, write for Bulletin 1147-ER today.

**HEVI-DUTY ELECTRIC COMPANY**

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*Heat Treating Furnaces... Electric Exclusively*

*Dry Type Transformers* *Constant Current Regulators*

## Personals . . .

**Mahlon E. Wood** has joined Reynolds Metals Co., Louisville, Ky., as special representative in the automotive market sales division in Detroit. Mr. Wood came to Reynolds from the Ford Motor Co., Dearborn, Mich., where he was a manufacturing research engineer. Prior to that he was a materials engineer with General Motors Corp.

**Henry T. Meador** has taken a position as assistant professor in mechanical engineering at the University of Washington.

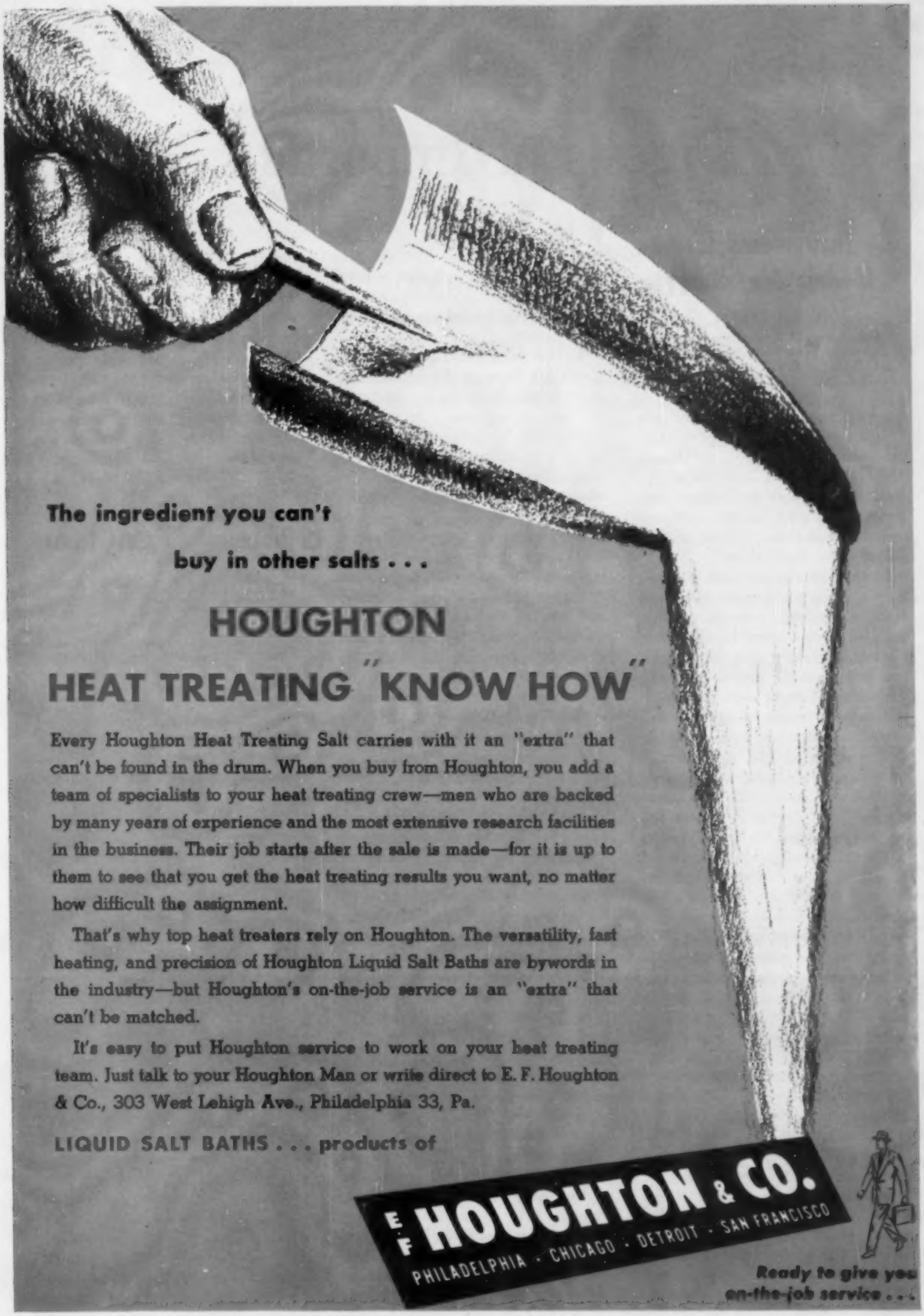
**R. E. Hueschen** has transferred from the Hanford Atomic Products Operation of General Electric Co., Richland, Wash., to the vacuum tube engineering section of General Electric's X-Ray Dept., Milwaukee, Wis. Mr. Hueschen's new position in Milwaukee will be as a ceramics and materials engineer.

**S. Sydney Minault** recently was appointed vice-president of the National Research Corp., Cambridge, Mass. Mr. Minault joined National Research in 1953 and has served as general manager of the company's equipment division for the past two years. Prior to joining the company, he was vice-president of Tracerlab, Inc., Boston, Mass.

**W. H. Ferguson** has been named eastern regional manager of a new eastern sales office recently opened in Phillipsburg, N.J., by Electro Metallurgical Co., a division of Union Carbide and Carbon Corp. This office was formerly located in New York City.

**Wilbur G. Bischoff** has been promoted to the post of metallurgical engineer in charge of customer service work in the steel division of the Timken Roller Bearing Co., Canton, Ohio. Associated with the company since 1924, Mr. Bischoff last held the position of metallurgical engineer in production.

**William A. Mossner**, until recently studying at the Michigan College of Mining and Technology, is now on a training program with the heating and forging division of the metallurgical department, Ladish Co., Cudahy, Wis.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Every Houghton Heat Treating Salt carries with it an "extra" that can't be found in the drum. When you buy from Houghton, you add a team of specialists to your heat treating crew—men who are backed by many years of experience and the most extensive research facilities in the business. Their job starts after the sale is made—for it is up to them to see that you get the heat treating results you want, no matter how difficult the assignment.
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# Digests of Important Articles

## Instruments for Modern Metallurgy

Digest of "New and Improved Metallurgical Techniques", by C. Sykes, *Journal* of the Institute of Metals, Vol. 84, April 1956, p. 287-290.

IN THE PAST 20 years many new instruments for use in metallurgical research have been developed. The 1955 Autumn Lecture of the Institute of Metals in England was devoted to a brief description of new techniques that have evolved through use of these instruments.

In the field of chemical analysis, the photo-electric absorptiometer has made it possible to obtain accurate analyses of steel more rapidly using fractional volumes of a single solution to analyze the various elements. Various methods of electrolytic separation and paper strip and column chromatography have facilitated such problems as the separation of columbium from tantalum. Analysis of steel with direct-reading spectrographs using electronic devices has become possible since World War II.

The use of radioisotopes produced in atomic piles has simplified the study of self-diffusion in metals and binary alloys, such as brass, and has helped to determine whether $SO_2$ or $SO_3$ in flue gases is responsible for sulphate deposits in boilers.

In optical microscopy, the application of dark-field illumination, polarized light, phase-contrast microscopes, and anti-reflection coatings for lenses are mentioned as new improvements. With the phase-contrast system, slip can be detected at an earlier stage of strain than in other ways. Reflecting microscopes have some advantage over refractors, in being more extensively achromatic, and in having a longer working distance (which helps with hot specimens). The study of dislocations in atomic structures has been promoted by Tolansky's development of multiple-beam interferometry. A "flying-spot" microscope, in which the field of view is scanned by a spot of light, can be used with a photo-electric cell to count grain boundaries and inclusions rapidly.

In electron microscopy recent emphasis has been on the development of reflection techniques, obviating the use of replicas. An electron micrograph of carbide precipitation in an austenitic steel is presented, supporting the chromium-impoverishment theory of intercrystalline corrosion.

Cameras for X-ray diffraction studies at high temperature are now commercially available. Segregation and precipitates in complex alloys can now be examined by applying characteristic radiation and its anomalous absorption near the absorption edge, and by autoradiography using a radioactive isotope of an element in the alloy to darken a contact print made from a specimen section.

The development of neutron diffraction in connection with atomic piles has proved more effective than the usual X-ray diffraction technique in locating light atoms among heavy atoms, and in detecting atoms whose nuclei differ in magnetic properties. Measurements of the resonance of the magnetic moments of atomic nuclei is expected to be helpful in structural studies.

The technique of zone melting for purification of metals has been applied in instances where there is a reasonable interval of concentration between the solidus and liquidus curves of the metal-impurity system, and has reduced an impurity in an aluminum rod from 10 parts to 1 part per million, in three meltings.

Instruments and techniques for plant investigations and production control have also been improved. Pyrometers for immersion in molten steel, and for measuring low surface temperatures in heat treatment, are widely in use. The Jominy hardenability test, S-curves depicting transformation rates, electric strain gages, and special creep test machines are listed as other modern advances. Radiography is now practiced largely with radioactive isotopes from atomic piles, instead of with radium. Supersonic apparatus has also proved very useful for nondestructive examination of large forgings, as well as for determining elastic constants. The new electronic computers are helpful in theoretical metallurgy.

GEORGE F. COMSTOCK

## Pinholing in Cast Irons

Digest of "Pinholing in Cast Iron and Its Relationship to the Hydrogen Pick-Up From the Sand Mould", by J. V. Dawson and L. W. L. Smith, *Journal of Research and Development*, British Cast Iron Research Association, Vol. 6, June 1956, p. 226-248.

PINHOLING generally refers to a layer of small, nearly spheroidal blowholes situated just below the surface of a casting. Close examination reveals the presence of a continuous film of graphite on the surface of the blowholes. It has been known for some time that a graphite film will occur on the surface of cast iron which has been heated for some time in an inert or reducing atmosphere and it was suggested that the pinholes arise from the evolution of hydrogen picked up by the reaction of molten metal with the moisture of the mold.

A method was devised so that the metal could be run through a sand channel and collected in a graphite chill mold. A sample of metal was taken directly from the ladle to a similar graphite chill mold so that a comparison of the hydrogen content of the two samples would give an indication of the tendency of the metal to pick up hydrogen from the sand. No absolute figure can be obtained but the results are comparable. Preliminary tests showed

# BRASS keeps sales up... manufacturing costs down

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7. Brass stands up under alternate heating and cooling.
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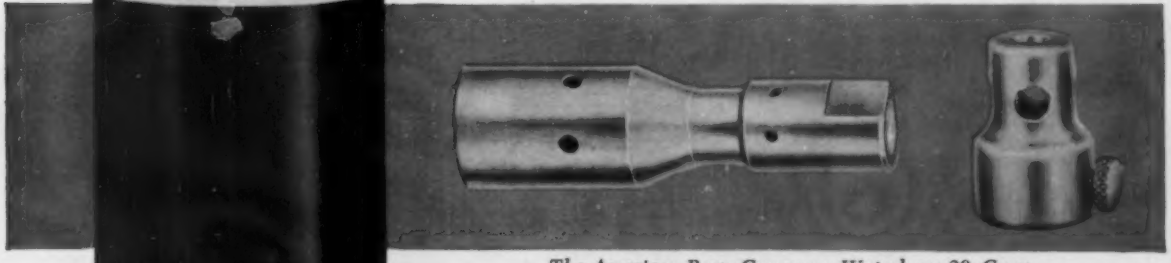
9. Brass gives superior wear on valve seats.
10. Brass has high public acceptance as a quality material.

Turner liquefied petroleum torch No. LP-533, with disposable fuel tank. Below are accessories of brass—holder for soldering tip and a heavy-duty burner.



*The American Brass Company, Waterbury 20, Conn.*
*In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

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## Pinholing . . .

there is a definite pick-up in hydrogen after pouring through the molds and that it is greater in green sand than in dry sand molds and that high-manganese austenitic iron picked up very much more hydrogen than did other irons.

Several heats were cast with varying manganese contents at different temperatures through a variety of sand molds. These showed that hydrogen pick-up is greater:

1. With increasing manganese.
2. With increasing temperature.
3. In green sand molds.
4. In the presence of coal dust (normal black sand).

In addition to the graphite chill molds, sets of plates were cast to study the effect of the conditions on pinholing. Only the plates with a hydrogen content of over 5 parts per million showed any pinholing.

The association of pinholing with aluminum additions has long been suspected and a series of heats showed that as little as 0.01% aluminum gave a remarkable increase in hydrogen pick-up and this increase continued up to 0.04%. No great change was noted between 0.04 and 0.10% and above 0.10% the pick-up diminished.

Aluminum is likely to cause more pinholing when titanium is present. Titanium alone does not markedly affect the pick-up of hydrogen. Pick-up of hydrogen is greater in black sand than in red sand—although pinholing is less likely to occur in black sand. No significant correlation was noted between hydrogen pick-up and the pinholing tendency.

Studies also showed that while hydrogen pick-up is proportional to the magnesium content, pinholing in the presence of magnesium occurs only when the iron has been inoculated with ferrosilicon. Pinholing is much less likely to occur when the magnesium content is above 0.10%. Small aluminum additions have an effect similar to ferrosilicon but aluminum over 0.20% prevents pinholing and reduces the hydrogen pickup.

Whenever pinholing occurred, the hydrogen pick-up was high although the converse was not always true. It therefore appeared that hydrogen could play a major part in the pinholing problem although it is not the only factor. Accordingly heats were prepared with increasing hydrogen content and it was shown that the pinhole tendency increased with rising hydrogen content. In this instance, black sand did not appreciably suppress the pinholing.

From the practical point of view, the above results suggest that the foundryman can reduce his pinholing problems by the use of ample coal dust or pitch in his sand and by avoiding combinations of traces of aluminum and titanium in gray irons and nodular iron. However, among the large variety of castings produced by the foundry industry, it is very likely that there are some which are very much more prone to pinholing than the irons used in these experiments. Furthermore, some other metal compositions may be more prone to the defect than those reported.

C. W. McKee.


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HILL ACME BAR BILLET SHEAR
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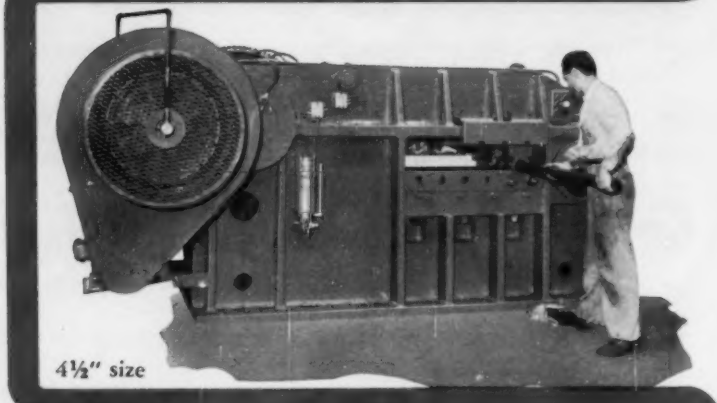

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- You'll be amazed at it's performance. You'll be surprised at the price.
- Made in 3", 4½", 6½" sizes and larger. Choice of hand, semi-automatic or fully automatic feed.

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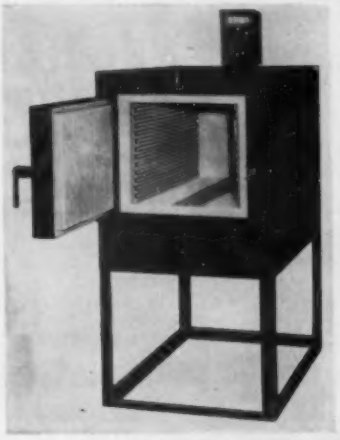
Metal Progress

# Bulletin Board...

The Buyers Guide For Metals Engineers



More than two thousand satisfied users WILL TESTIFY YOU

## SAVE 3 WAYS WITH A LUCIFER FURNACE

### 1—Save on First Cost

CHECK THESE PRICES

| Furnace Size | 2000° | 2300° |
|---|---|---|
| 6x 6x12" | $ 500.00 | $ 600.00 |
| 9x 9x18" | 750.00 | 850.00 |
| 12x12x24" | 1000.00 | 1100.00 |
| 18x18x36" | 1500.00 | 1600.00 |

Complete with 100% automatic electronic controls.

### 2—Save on Man Hours

Less operator attention needed—Lucifer controls are EXACT. They reach SPECIFIED heat rapidly and retain SPECIFIED temperature without variation. No special experience required when you use a Lucifer Furnace.

### 3—Save on Maintenance

Finest refractory materials are built into Lucifer Furnaces for better, more efficient heat retention. Elements are guaranteed, long lived, trouble free.

**WRITE FOR FREE LITERATURE, specifications and price list of Lucifer Furnaces in wide range of sizes—top loading and side loading types. Engineering advice without obligation. Write, wire or phone today.**

**LUCIFER FURNACES, INC.**

[illegible] 5-0411

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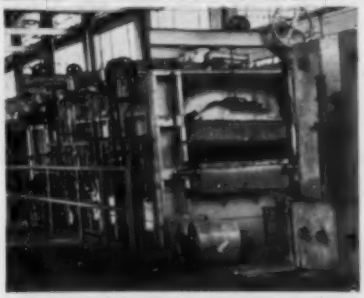
## GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!



**FURNACE ENGINEERS, INC., CATENARY** type furnace with venturi eductor system. Inside work dimensions 5'3" wide x 30' long x 3'9" high. Gas fired and complete. Like new condition.

Cost $30,000. Our price $9900.

- We Buy—Sell—Lease—Rent!
- Specialists in Heat Treating—Melting — Forging — Plating — Cleaning Equipment.
- 3000 Furnaces
- Modification to Your Specs.
- Money Back Guarantee!
- Immediate Delivery!
- 16,000 Sq. Ft. Heated Warehouse
- Warehouses in Major Cities.

PLEASE SEND YOUR REQUIREMENTS OR CALL COLLECT TOwnsend 8-8450

**METAL TREATING EQUIPMENT EXCHANGE, INC.**
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

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## Inducto

### THE INDUCTION MELTING FURNACE WITH PRECISION CONTROL

Here is induction metal melting equipment at its best!

NEW FURNACE DESIGN . . . Sturdy, welded construction eliminates distortion and increases lining life.

NEW COMPACT CONTROL . . . Totally enclosed panels include built-in capacitor bank, selector switches and high frequency transformer. Compact design for efficient operation and shipped completely assembled.

WATER COOLED LEADS . . . Introduced through trunion. No furnace pits necessary. Shorter leads mean more operating efficiency.

SELECTOR SWITCHES . . . Mounted on lower front of control panel for maximum accessibility and minimum bus losses. You can change furnaces in a few seconds.

For details, write for our Bulletin 70.

INDUCTO INDUCTOTHERM CORPORATION [illegible] ILLINOIS AVE.

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# Upton

. . . . OFFERS
the most advanced
Salt Bath **Furnaces**
FOR . . . .

***BATCH***

***CONVEYORIZED***

***ALUMINUM BRAZING***

***with continuing graphite electrodes***

**UPTON ELECTRIC FURNACE CO.**
**30435 Groesbeck**
**Roseville, Michigan**
**Phone: Prescott 1-1200**

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*New*
## WIRETEX STEEL BASKET

**MOVES 5 TON LOAD of HEAVY CASTINGS FROM HEATING TO QUENCHING . . .**

**Eliminates Secondary Handling!**
Here is another example of WIRETEX ingenuity to expedite traffic . . . to save money, time and increase production. Made strong to carry loads up to 10,000 lbs. Versatile! It's Big!

**If you have a material handling problem, consult**

*Specialists in Processing Carriers Since 1932.*

**Wiretex mfg. co.**
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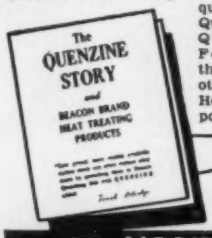
## FREE
### the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .




**ALDRIDGE INDUSTRIAL OILS, Inc.**
**3401 W. 140th St., Cleveland 11, Ohio**

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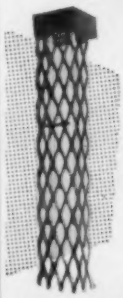
there's a
## Glo-QUARTZ* IMMERSION HEATER
*for*
**Your Every Heating Requirement**



- INSTANT HEATING
- SHOCK-PROOF
- AVAILABLE IN ALL VOLTAGES —WATTAGES, ONE AND THREE PHASE

Available from your Electroplating Distributor

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**Glo-QUARTZ**
ELECTRIC HEATER CO., INC., Willoughby, Ohio
*Reg. U. S. Pat. Off. Phone: Willoughby 2-5521

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# STANWOOD

HEAT TREATING EQUIPMENT • BASKETS • TRAYS
FIXTURES • RETORTS • CARBURIZING BOXES • FURNACE PARTS
*EVERY SIZE, EVERY SHAPE, EVERY HEAT AND CORROSION RESISTANT ANALYSIS*

*Stanwood* (S) *Corporation*
4817 W. CORTLAND ST. CHICAGO 39, ILLINOIS

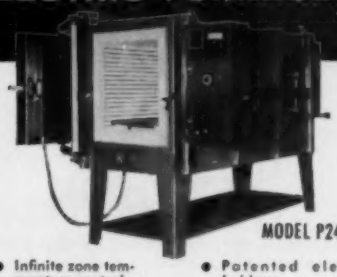
SEND FOR THE COMPLETE STANWOOD CATALOG

LIST NO. 12 ON INFO-COUPON PAGE 169

## dyna-trol ELECTRIC FURNACES

| MODEL NO. | FIRING CHAMBER (H.W.D.) | PRICE (300° to 2000°) | PRICE (400° to 2300°) |
|---|---|---|---|
| P46 | 4½"x4½"x6" | $90.00 | $110.00 |
| P79 | 6"x6"x9" | $205.00 | $225.00 |
| P918 | 9"x9"x18" | $480.00 | $528.00 |
| P414 | 14"x14"x14" | $525.00 | $603.25 |
| P124 | 12"x12"x24" | $715.00 | $822.25 |
| P818 | 18"x18"x18" | $775.00 | $887.50 |
| P136 | 18"x18"x36" | $1125.00 | $1312.50 |

Automatic Controls Available on all Models



MODEL P2472-1

MODEL P-79

- Infinite zone temperature control.
- Zone temperature indication by Pyrometer Selector Switch.
- Automatic hold and cut-off instrument available.
- Patented element holders.
- Infinite variety of time-temperature curves obtainable.
- Rugged construction. Highest quality insulation used

OVER 40 STANDARD MODELS • WRITE FOR LITERATURE

L&L INDUSTRIAL DIVISION MANUFACTURING CO.
CHESTER 77, PA.

LIST NO. 138 ON INFO-COUPON PAGE 169

# RUST-LICK IN AQUEOUS SYSTEMS

Grade "B"
FERROUS METAL PROCESSING

Eliminates . . .
*Rust*
*Fire Hazards*
*Toxicity*
*Dermatitis*
*Degreasing*

*Write for free sample and brochure Specify Grade "B"*

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS

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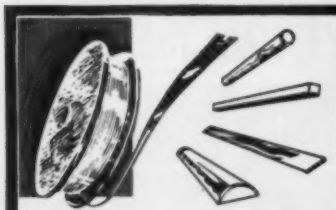

ROUND, SQUARE, FLAT AND HALF-ROUND WIRE FOR MASS PRODUCTION OF SMALL PARTS

Beryllium Copper • Bronzes
Other Non-ferrous Alloys
Rounded or square edges.
Available with hot-tinned finish for solderability.
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193 Caldwell Ave., Paterson 1, N. J.

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EXTREME PRESSURE?
EXTREME HEAT?
the answer is
Molylube
ANTI-SEIZE
(Molybdenum Disulfide)
THE ULTIMATE LUBRICANT FOR EXTREME HEAT AND PRESSURE APPLICATIONS
AMONG HUNDREDS OF APPLICATIONS, MOLYLUBE ANTI-SEIZE IS OUTSTANDING AS A:
• RUNNING-IN LUBRICANT
• ACID RESISTANT LUBRICANT
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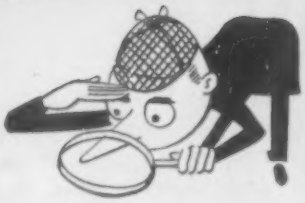
• HEAT REDUCER IN HOT RUNNING
FREE
We are so confident of ANTI-SEIZE's performance that we want you to try our sample tube at no cost or obligation. WRITE TO DEPT. D FOR FREE SAMPLE AND LATEST CATALOG.

...famous for the "MOLYLUBE" Series

LIST NO. 111 ON INFO-COUPON PAGE 169

# FREE Listing Service for Used Equipment



## Mr. Buyer — LOOKING FOR USED EQUIPMENT?

This new service on used heat treating equipment is completely without obligation to you. To receive the latest availabilities just drop us a line requesting to be placed on our mailing list for a monthly digest. What are your production requirements?

## Mr. Seller — WITH EQUIPMENT TO SELL!

Take advantage of the opportunity to list useful, but no longer needed used heat treating equipment. Send us details including manufacturer, type, size, capacity, original and asking price. Monthly digest will be mailed to all listed firms.

## ANOTHER HOLDEN SERVICE

This free listing is yours at no cost. CHECK WITH HOLDEN FIRST. Proven MONEY MAK-ER PRODUCTS.

THE A. F. HOLDEN COMPANY
MANUFACTURING PLANTS
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NEW HAVEN, CONN. (STate 7-5885)

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Swift

SOLUTIONS TO YOUR METAL TREATING PROBLEMS! . . . .

SWIFT BLACK

Activanium Blended— Positive blackening of every ferrous metal and alloy!

NOT GRAY
NOT FADED
NOT MOTTLED
BUT RICH, DARK, UNIFORM
BLACK

SWIFT CASE

Liquid Carburizer— For a tougher, more durable case!

SWIFT HEAT

Liquid Salt Baths— Temperature range 300° to 2500° F. . . . no decarburization!

RUST PREVENTATIVES

Sol-u-Kote— An emulsifiable rust protective, effective even under humid conditions.

METAL CLEANING PICKLING and PLATING COMPOUNDS

Acid additives, brighteners, bright dips and chromate conversion coatings!

Send today for literature and technical data sheets.

THE Swift INDUSTRIAL CHEMICAL CO.
Canton, Connecticut

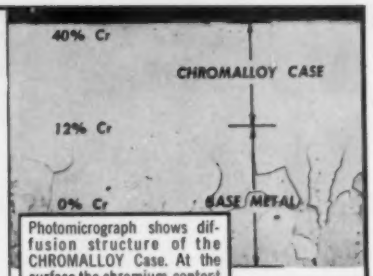
LIST NO. 92 ON INFO-COUPON PAGE 169

CHROMIZING PROCESS COMBATS . . .
HEAT
WEAR
CORROSION

CHROMALLIZING diffuses chromium into the surface of iron and steel parts, providing the corrosion resistance of stainless steel and the wear resistance of chromium carbides. CHROMALLOY Case cannot chip, peel or flake.

Chromalloy Corporation is fully equipped for processing large or small quantities of parts. Engineering advisory service available.

FREE! TECHNICAL BULLETINS



Photomicrograph shows diffusion structure of the CHROMALLOY Case. At the surface the chromium content is 35% to 45%.

Chromalloy CORPORATION
451 Tarrytown Road, White Plains, N.Y.
Telephone White Plains 6-0020

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DO YOU HAVE AN IDEA . . .

THAT SOME FUNCTIONAL METAL PART COULD BE MADE BETTER OR CHEAPER BY ALUMINUM EXTRUDING?

Bring your idea to specialists in adapting aluminum extrusions to new functional parts applications. G. E. I.'s engineers are ready to consult with you, without obligation, on one part or a million.

GENERAL EXTRUSIONS, INC.
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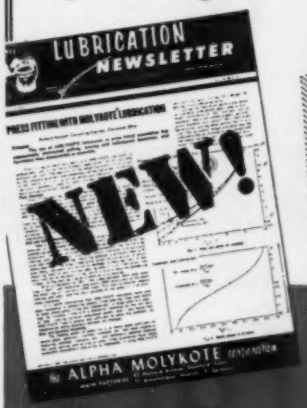
BERYLLIUM

New book contains papers and talks by 39 experts. Subjects covered are: reduction, processing and fabrication, properties, the brittleness problem, metallography, corrosion, beryllium-rich alloys, cermets and ceramics, health hazards and analytical chemistry of beryllium.

Price—$8.00

AMERICAN SOCIETY FOR METALS
7301 Euclid Ave.
Cleveland 3, Ohio

Engineering Data on MOLYKOTE® lubricants




- Being published regularly
- Every issue features a full-length technical article on the use of MOLYKOTE Lubricants in industry.
- "How-to" stories on tough lubrication applications
- Get on our mailing list TODAY. Write to

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Main Factories:
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71 Arnulfstrasse, Munich 19, Germany

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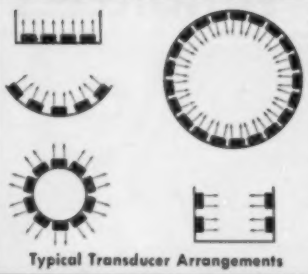
# ULTRASONIC CLEANING



Typical Transducer Arrangements

## SONOGEN®

Ultrasonic-Power Generators with hermetically-sealed barium-titanate Transducers — 40Kc/sec.

Transducer Radiating Areas of ¼ sq. ft. to 10 sq. ft. — for use in solvents and detergents.

Eliminates hand operations — Reduces rejects in plating, finishing, assembly.

For washing, degreasing, removal of buffing compounds, radioactive contamination, soldering flux, plaster, carbon smut, etc.

*Literature upon request.*

**BRANSON ULTRASONIC CORP.**

*Specializing in Ultrasonics Since 1946*

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ORIGINATORS OF DI-PHASE METAL CLEANING

# Solventol

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SOLVENTOL CHEMICAL PRODUCTS, INC. • DETROIT 3, MICHIGAN

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# JELLIFF BASKETS

*for ALL Industrial Uses*

- Degreasing
- Anodizing
- Pickling
- Plating
- Heat Treating
- Heavy Industrial Types

ANY SIZE AND SHAPE • ANY DUCTILE METAL

Ask for Bulletin 28

WIRE PRODUCTS JELLIFF SINCE - 1680

**THE C. O. JELLIFF MANUFACTURING CORP.**

SOUTHPORT • CONNECTICUT

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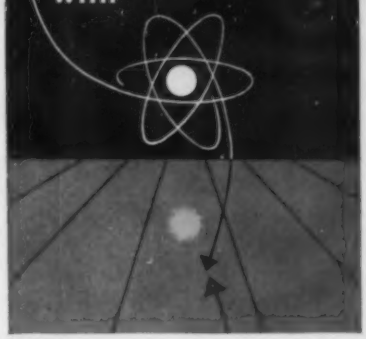
# TECHNIC

equips you to Electroplate Precious Metals with



## SCIENTIFIC PRECISION

Technic, Inc. equips you with controlled apparatus and electroplating solutions to maintain exacting standards and close tolerances. Typical benefits are the spectacular economies Technic effects in handling gold — where often electroplaters lose up to $60,000 or more of every $100,000 worth through outmoded equipment, inefficient methods and solutions.

### TECHNIC ENGINEERING

Technic engineers design and install your equipment — and stand by until performance is assured. *No installation is complete without this follow-through.*

### TECHNIC PRODUCTS

Technic Potassium Gold Cyanides, Concentrated Aqueous & Dry • Technic Electroplating Solutions: Rhodium, Platinum & Palladium • Technic Immersion Tin • Technic Protectox Anti-Tarnish • Technic Flame Flux

### TECHNIC EQUIPMENT

Technic Electroplating Systems • Technic Germanium Diode Rectifiers • Technic Turbomatic Agitators • Technic Electroplating Barrel Unit • Automatic Techni Timers

### TECHNIC BIBLIOGRAPHY

Technic publications, authoritative in our field: "Electroplated Gold"; "Precious Metal Electroplating Data: Gold, Rhodium, Palladium, Platinum, Silver, Nickel"; "Electroplated Platinum"; "Electroplated Palladium"; "Electroplated Rhodium"; "Analysis of Gold & Gold Alloy Solutions".

*Consult us without obligation, whether in respect to a new installation and electroplating solutions, or an existing system now in use. Write for Technic publications in your field of interest.*

**TECHNIC, INC.**

39 Snow Street,
Providence, R. I.
JAckson 1-4200
Chicago Office—7001
North Clark Street

TECHNIC INC PRODUCTS OF RESEARCH

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

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NEW pocket size thickness gauge
ELCOMETER

**Measures Non-Magnetic Coatings with ± 5% ± .0001″ Accuracy**

**ELCOMETER** measures thickness of porcelain enamel, paints, platings, foils, glass, paper, plastics, and other non-magnetic coatings quickly and accurately. Gauges flat or curved surfaces and hard-to-get-at spots easily. Needle locking device assures correct reading every time. Complete with tough leather case containing inner pocket for test strips. Weighs only 6 oz. Completely self-contained. Retail price: $68.00 F. O. B. Cleveland.

WRITE FOR ILLUSTRATED FOLDER

FERRO CORPORATION
4150 East 56th Street
Cleveland 5, Ohio

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WRITE, WIRE or PHONE FOR YOUR CATALOG Today

Star Stainless screws have clean—bright—shiny—heads

STAR STAINLESS SCREW CO.

CORROSION RESISTANT

647 Union Blvd., Paterson 2, N. J.
Telephone: Little Falls 4-2300
Direct NEW YORK 'phone W17-9041

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GET A BID FROM

HOOVER

SPECIALISTS IN THE FIELD OF

Die Castings

SINCE 1922

*Aluminum and Zinc*

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio

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TENSILKUT
Patent Pending

Accurate test specimens machined from sheet and plate materials .0005 to .500 in., in less than 3 min.

SIEBURG INDUSTRIES, INC.
Horse Plain Rd. • New Britain, Conn.

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**ENGINEERING ALLOYS**
*by N. E. Woldman*

This up-to-the-minute book lists over 19,000 alloys by trade name and gives their properties, compositions and typical applications. All important commercial alloys are shown.

1056 pages of valuable information, generous index and tables of manufacturers and the trade names of their products.

*Price, $15.00*

AMERICAN SOCIETY FOR METALS
7301 Euclid Ave. Cleveland 3

**Precious Metal Processes**
**FOR INDUSTRIAL APPLICATIONS**

Developed *specifically* for industrial application, Sel-Rex Precious Metals offer many advantages over conventional processes. *One gram* of Sel-Rex BRIGHT GOLD, for example, *does the job of 2 grams* of regular 24 K. gold, because the deposits are more dense and twice as hard. Gives mirror bright finish directly from the bath, regardless of thickness requirements — eliminates costly scratch brushing, buffing and burnishing.

Sel-Rex BRIGHT RHODIUM meets the need of today's precise engineering applications with A. S. C. — Automatic Stress Compensation — a special technique which counteracts the high stress characteristics of conventional precious metal electroplates. Non dusting Sel-Rex Silver SOL-U-SALT is added directly to the plating bath, eliminating time consuming filtering or mixing — a cost cutting advantage exclusive with Sel-Rex.

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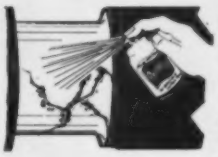
## DYELINE INSPECTION PROCESS



Dyeline—a new two-stage inspection process for all non-porous materials. No skilled operator or expensive equipment necessary! Just spray Dyeline, follow with Dyeline Detector, and the exact location, type and extent of defects appear sharply and clearly on an opaque background! No solvent required—water removes Dyeline immediately.

*WRITE FOR DETAILS*

**ZACO LABORATORIES**
1360 W 9th St. • Cleveland 13, Ohio

**ALSO:**

**ZIP SPEED LACQUER**—Identifies all materials with a quick color-coding process.

**ZIP RUST STOPPER #1** Protects metal parts for storage.

**ZIP RUST STOPPER #2** Protects parts left in machinery for further processing; removes fingerprints.

**ZIP PATTERN LAYOUT FLUID**—Shows up scribed patterns strongly.

**ZIP STENCIL INK**—Quick drying—excellent on cartons and metals.

**ZIP BELT LUBE**—Prolongs belt life; promotes safety and speed.

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## HARDNESS TESTING
## SHORE SCLEROSCOPE

***Pioneer American Standard Since 1907***

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

**OVER 40,000 IN USE**

**SHORE INSTRUMENT & MFG. CO., INC.**
90-35M Van Wyck Exp., Jamaica 35, N.Y.

LIST NO. 133 ON INFO-COUPON PAGE 169

## KENTRON
MICRO HARDNESS TESTER

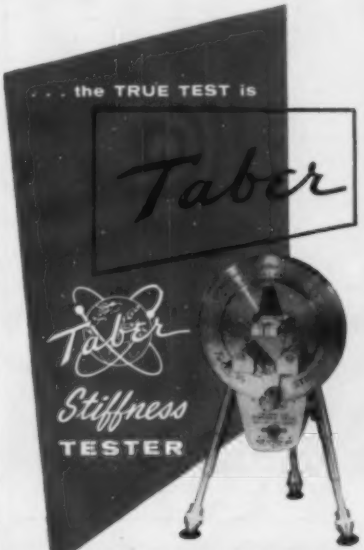
**Applies 1 to 10,000 gram loads**
*Write for Bulletin*

**Kent Cliff Laboratories Div.**
**The Torsion Balance Company**
**CLIFTON NEW JERSEY**

LIST NO. 53 ON INFO-COUPON PAGE 169

. . . the TRUE TEST is

*Taber*




Determines the initial, basic stiffness or resilience of sheet and wire specimens, including cellophane and metal foil. Eight test ranges provide wide application, up to 100X. Test length, angle of deflection, rate of loading all standardized for accurate results between laboratories. Scale calibrated in gram centimeters.

**TABER** *Abrasion* **TESTER**

Tests wear resistance of metal, plastic, paint, rubber, leather, paper, foil, etc. With average technical experience, anyone can make a scientific, comparative abrasion resistance test with this instrument.

Write for Illustrated Literature.

**TABER INSTRUMENT CORPORATION**
SECTION 19
111 Goundry St., N. Tonawanda, N. Y.

LIST NO. 109 ON INFO-COUPON PAGE 169

## *Inspection Demagnetizing or Sorting* PROBLEMS?

## *SOLVED with*

### MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

**Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.**

**Over 80 installations in steel mills and fabricating plants.**

### MAGNETIC ANALYSIS SPECIAL EQUIPMENT

**Electronic Equipment for non-destructive production inspection of both non-magnetic stainless and high temperature steel bars and tubing—seamless or welded—as well as non-ferrous bars and tubing. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed 200 ft. per minute.**

**Over 30 installations in mills and fabricating plants.**

### MAGNETIC ANALYSIS COMPARATORS AND METAL TESTERS

**Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.**

### MAGNETIC ANALYSIS DEMAGNETIZERS

**Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.**

### MAGNETIC ANALYSIS MAGNETISM DETECTORS

**Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.**

*For Details Write:*

**MAGNETIC ANALYSIS CORP.**
42-44 Twelfth St., Long Island City 1, N. Y.
"THE TEST TELLS"

LIST NO. 51 ON INFO-COUPON PAGE 169

the GRIES
MICRO-REFLEX
HARDNESS TESTER
Loads: 10 to 3000 gram
with CARL ZEISS Optical System
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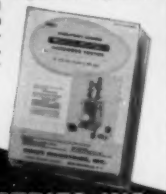

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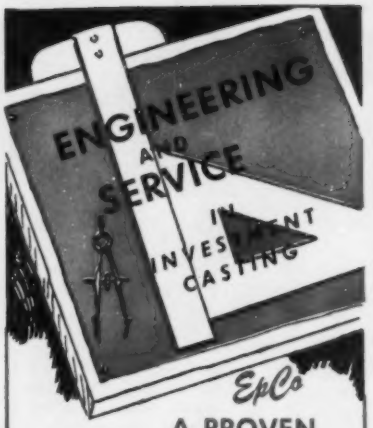


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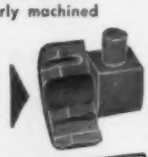

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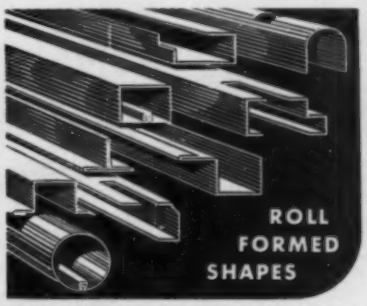


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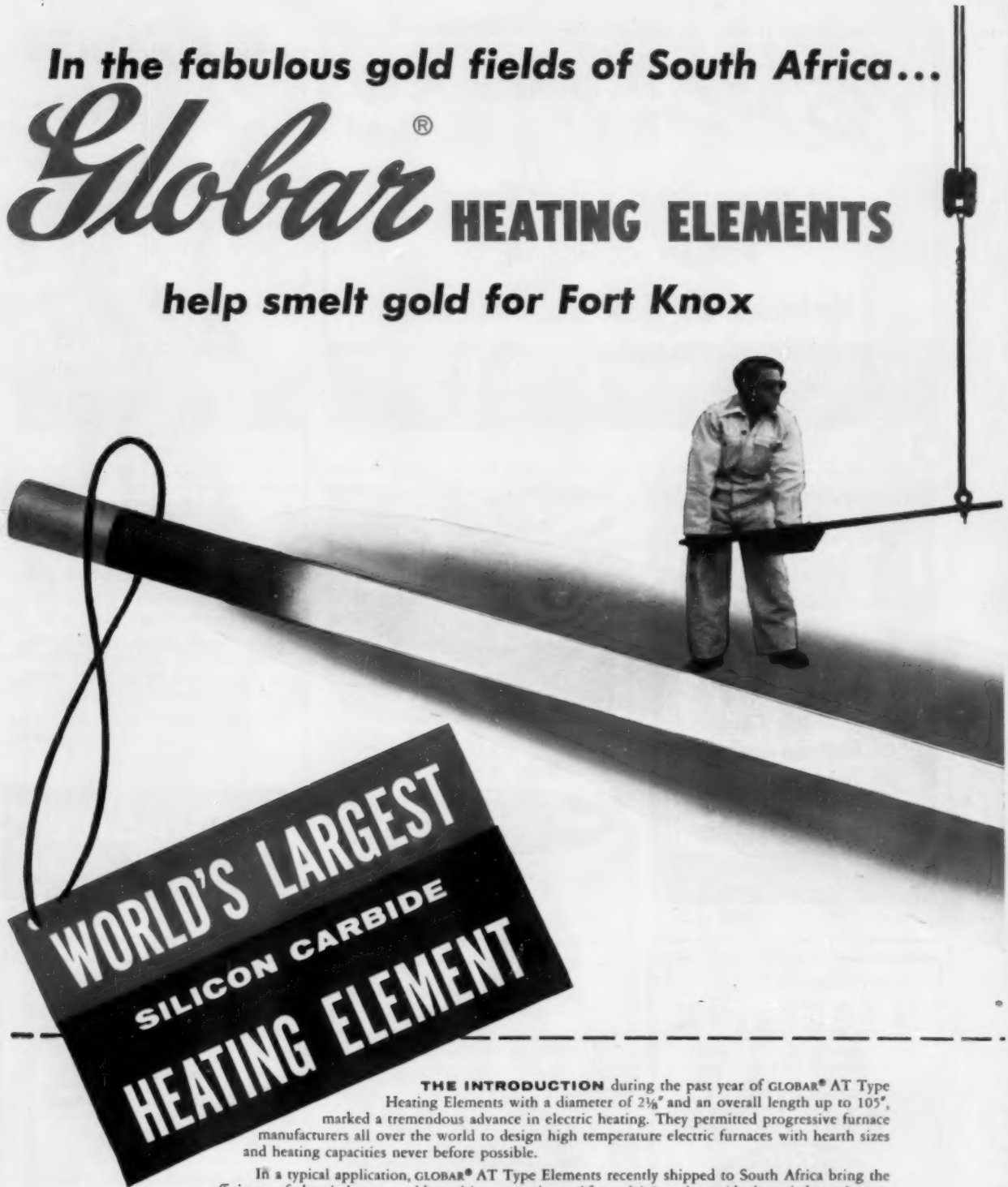


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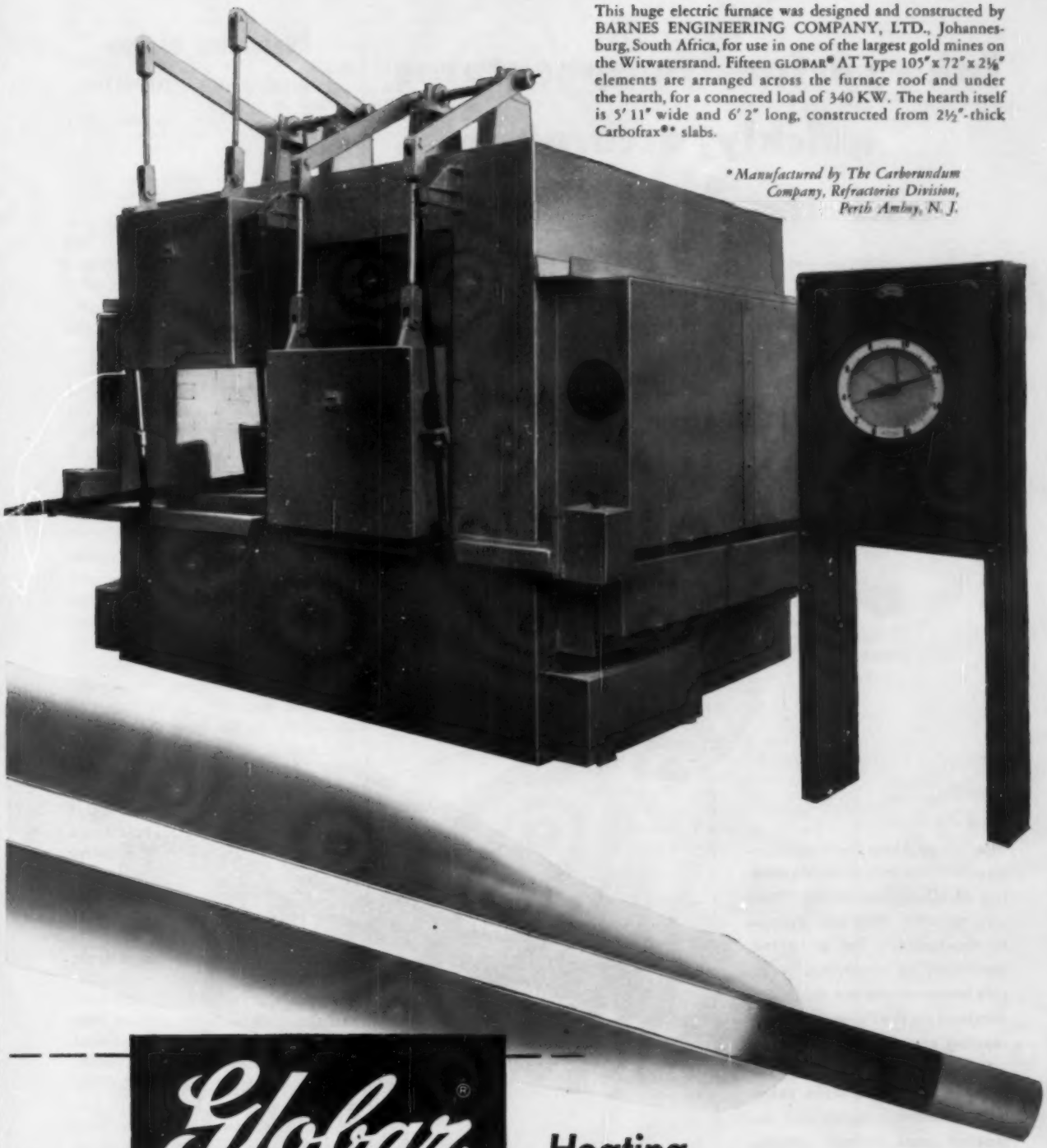

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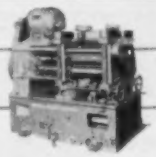
## Evaluation of Low-Temperature Properties

Digest of "The Hardness of Some Carbon and Low Alloy Steels at Low Temperatures", by R. W. Nichols, *Journal* of the Iron and Steel Institute, Vol. 182, April 1956, p. 348-354.

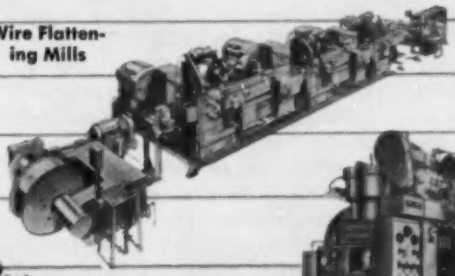
IN AN INVESTIGATION of the relationship between hardness and tensile properties of carbon and alloy steels at 65, −95 and −320° F., it was found that the simpler hardness tests can yield much of the information provided by the more tedious and difficult low-temperature tensile tests. Hardness tests, of course, cannot predict the amount of deformation a tensile specimen will withstand before fracture. That would be too much to expect since the stress state has a much greater influence on ductility than on strain hardening or strength.

The hardness tests were made with a Vickers testing machine with minor modifications. The dimensions of impressions made at the temperature of interest were subsequently measured at room temperature. The steels represented a variety of compositions and heat treatments. As expected, the hardness increased as the testing temperature decreased. The hardness increases ranged around 120 numbers on the Vickers scale when the temperature dropped from 65 to −320° F. The change was more marked for the softer steels.

The percentage change in hardness with decreasing temperature was very similar to the change in ultimate strength for the same steels. This means that the conversion factor for the relationship between strength and hardness at room temperature gives reliable correlations at low temperatures. In this study, the coefficent of variation for the factors converting hardness to tensile strength was only 2.7% even though the data were obtained on eight steels each tested at three temperatures. The ratios between hardness numbers and the stresses producing 8% strain in tensile tests showed only about half as much variation. These data provide strong support for Tabor's suggestion that the Vickers test measures the pressure required to produce an average strain of 8% under the indenter. Tabor's earlier work indicated that

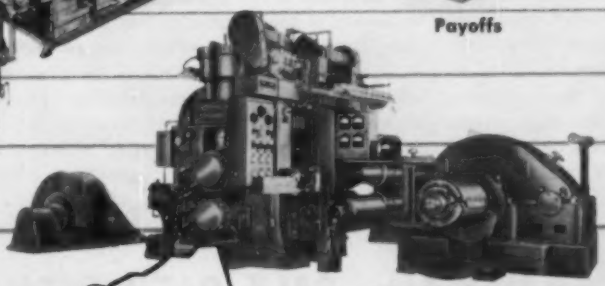


Coilers

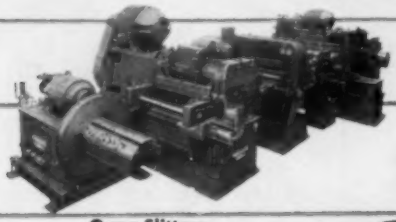


Wire Flattening Mills

Payoffs



Two High Strip Rolling Mills



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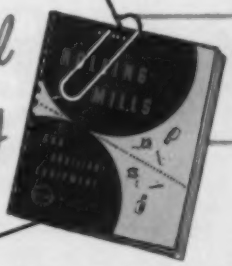
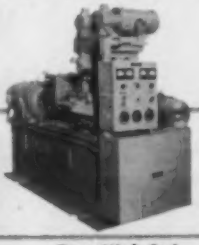
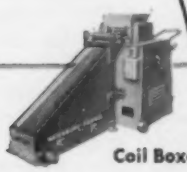




Four High Strip Rolling Mills



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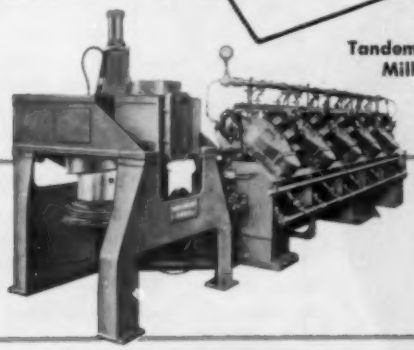
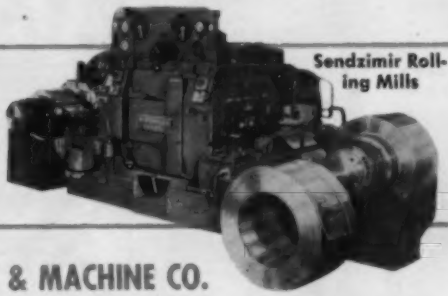


Tandem Rod Mills



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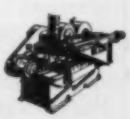

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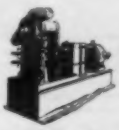

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## Low Temperatures . . .

a constant ratio exists between the yield stress and the stress producing deformation under the hardness indenter. Hence, the constancy of the ratio of ultimate strength to hardness found by Nichols indicates that all the steels tested had similar strain hardening characteristics between 8% strain and the strain at the start of necking.

Nichols found that the ratios of tensile strength to hardness were about 1.5% less at −320° F. than at higher temperatures. He attributed this variation to slower rates of work hardening at the lower temperature and to the fracture of some tensile specimens before necking occurred. To check the first explanation, Nichols secured data with ball indenters at several loads at each of the three temperatures of interest. He found that the rate of work hardening was virtually constant for each alloy in the tests at 65 and −95° F. However, the rate of work hardening was significantly lower at −320° F. than at higher temperatures for five of the eight steels. There is no obvious explanation why temperature had less effect on the work hardening coefficients of the other three steels.

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Ajax Electrothermic Corp.

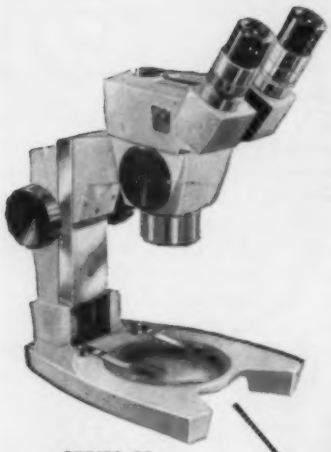

## Desulphurization of Pig Iron With Lime

Digest of "Desulphurization of Liquid Pig Iron by Blowing With Lime Powder", by B. Trentini, L. Wahl and M. Allardi, *Journal* of the Iron and Steel Institute, Vol. 183, June 1956, p. 124-133.

DESULPHURIZATION PRACTICE has often been inefficient because of improper mixing of the desulphurizing agent with the molten pig iron. Some methods have been objectionable to workers due to disagreeable dust and fume or have been highly corrosive to the acid linings in iron ladles and mixers.

Since desulphurization must be carried out under reducing conditions, many attempts to overcome the mixing problem have been made by blowing powdered lime, calcium carbide or calcium cyanide in a stream of nitrogen into the molten iron. This is usually done with a single graphite tube immersed in the molten metal. Some claim very good results with this practice while others report quite unsatisfactory results since a single injection lance in a large ladle does not give uniform mixing of the reagent with the molten pig iron. In addition, much longer blowing is required in the single-lance method to get a satisfactory reduction of sulphur, and this causes a considerable drop in temperature of the hot metal, sometime as much as 150° F.

The authors overcame many of these difficulties by blowing finely powdered lime (less than 100 μ) in a stream of high-pressure nitrogen into the molten iron for periods of 3 min. Initial work was done in a 300-kg. experimental converter at the research laboratory, but most of the investigation was conducted in a 2.5 metric ton converter at Pont-à-Mousson Steel Works. The results



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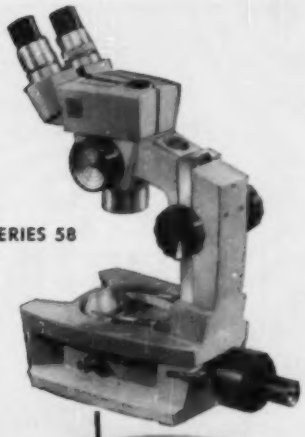

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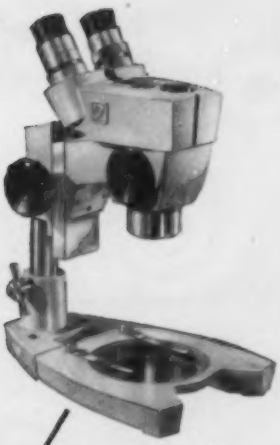

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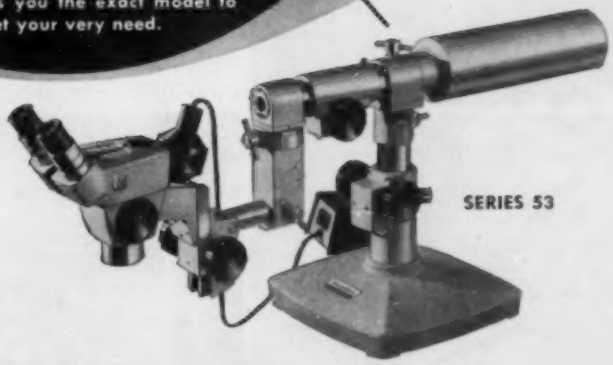

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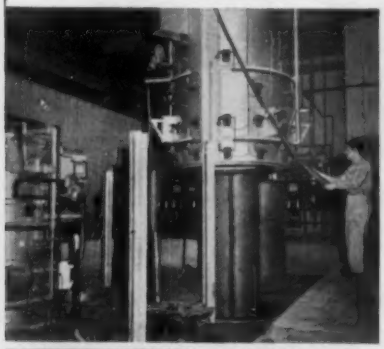

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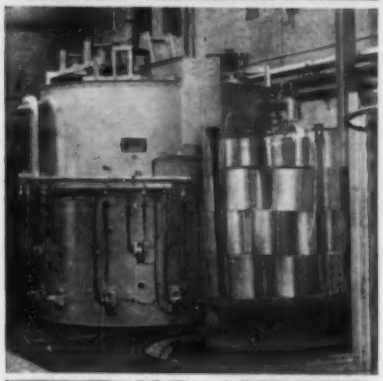

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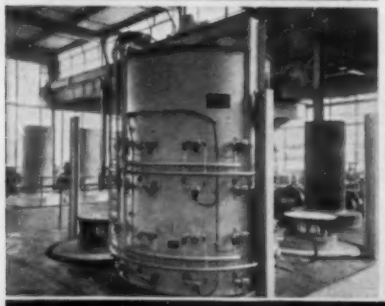

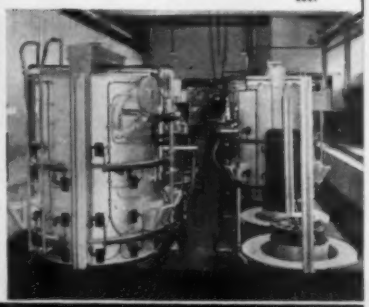

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## Desulphurization . . .

of both tests were so favorable that additional work was done in a specially constructed transfer ladle which permitted desulphurization of hot metal for either the openhearth furnaces or basic bessemer converters to be done without interfering with the normal production operations of the converters. This ladle was so constructed with tuyeres that in both the carrying and pouring positions the tuyeres were above the molten bath and a simple rotation allowed them to be immersed during the blowing period.

More than 200 desulphurization tests were carried out on liquid pig iron of different chemical composition and at different temperatures. The silicon contents of the melts treated varied from 0.4% for basic bessemer hot metal to more than 3% for foundry irons. The phosphorus contents also covered a wide range, from the very low contents of hematite pig iron to about 2% for basic bessemer hot metal. Pig irons with high nickel contents (25%) were also treated.

The sulphur contents of these irons varied between wide limits; in most instances, they were between 0.060% and 0.120%; however, certain tests were made on pig irons containing up to 0.300% sulphur.

Temperatures at the start of treatment varied with operating conditions; the usual range of variation was from about 2200 to 2600° F.

The powdered lime used was obtained from a French steel plant where the raw limestone was calcined in a rotary kiln fired with blast-furnace gas. The lime contained from 89 to 96% CaO and sulphur content varied between 0.07% and 0.13%. Between 70 and 80% of the particles were smaller than 100 μ. About 18 kg. of lime was blown into the 2500-kg. bath per minute and the desulphurization to under 0.01% sulphur was complete in 3 min. The desulphurization was 75% complete in 2 min. and 95% in 3 min. This is far better than any other method with respect to final sulphur content and desulphurizing efficiency.

Whether carried out in a converter or a ladle, the desulphurization operation is very simple. The liquid pig iron is poured into the

Jack Berger, General Foreman, Lehmann-Brandes Machine Company, St. Louis, Mo., and R. A. Loughman, Gulf Sales Engineer, watch George Mayer operate his turret lathe on Gulfcut. Gulfcut oils excel over a wide range of metal cutting applications—this firm uses Gulfcut exclusively on gear shapers, milling machines and all other machining operations, for long tool life, lower costs.

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## Desulphurization . . .

vessel with the tuyeres remaining above bath level; during the pouring, the introduction of unwanted slags such as blast-furnace or mixer slags must be avoided as far as possible.

After a sample of the melt is taken, nitrogen is admitted and then the lime. As soon as a white cloud appears at the mouth, the tuyeres are immersed by simply rotating the vessel for the duration of the test which is only a few minutes. At the end of this time, the vessel is returned to its starting position with the tuyeres above the bath, and the supply of lime and nitrogen is cut off. After taking a sample of metal, the tuyeres are disconnected from the lime and nitrogen supply system and the desulphurized iron is poured off, either after preliminary skimming of the used lime or without such preliminary skimming. The lime is easily held back during the pouring and eliminated afterward by a complete turndown.

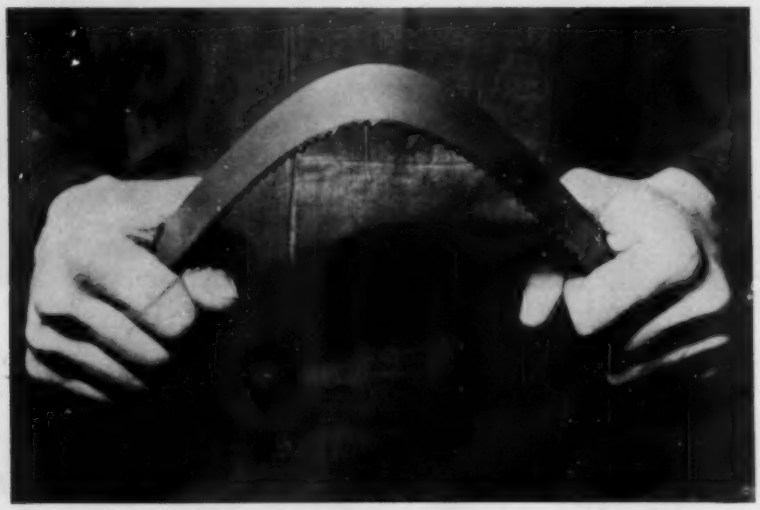
It was found that highly oxidizing slag containing much iron silicate was detrimental to the lime efficiency, and it should be skimmed if possible before blowing with lime. This difficulty was overcome by introducing 2% Al or Mg to the lime. These strong deoxidizers overcame the oxidizing slag effect and resulted in final sulphur levels below 0.004%. In the large ladle, only 18 kg. of lime per metric ton was needed for complete desulphurization. Since the ratio of lime to nitrogen was 38 kg. per cu.m. only about 1.5 m. of nitrogen was required for a 3-min. blow. This is about ½ cu.m. per metric ton of hot metal. In all of these nitrogen-lime blows, the decrease in silicon and carbon content of the hot metal was very slight even though commercial-quality nitrogen containing 0.5% oxygen was employed. In one example, carbon was reduced from 3.4 to 3.25% and silicon from 3.0 to 2.8%.

Using an entirely opposite approach, a series of desulphurization tests was carried out with compressed air as the carrying medium. The weight of lime used corresponded to 2.2% of the weight of the iron treated and the total duration of the operation was 6 min. The sulphur content of the iron decreased from 0.062% at the start to 0.012% at the end of the treatment, representing a desulphurization efficiency of 80%. The carbon content does not vary appreciably during treatment at 2460° F. nor does the phosphorus content suffer any change, but the silicon decreases from 1.65 to 1.42%.

It is quite apparent that a considerable degree of desulphurization is possible even using compressed air as the carrier gas for the lime powder. This may appear paradoxical and contrary to the principles already stated relative to the danger of oxidizing conditions. In practice, one must not lose sight of the fact that one of the characteristics of the process dealt with in this paper is the blowing of lime at a very high concentration in a carrier gas, so that the amount of oxygen carried in, when compressed air is used, is still very slight.

Calculations of the temperature drop in the molten metal in this operation, based on blowing 20 kg. of lime and 1 cu.m. of nitrogen per ton of hot metal, indicate a decrease of about 40° F. No actual measurements of this are given in the paper. No increase in nitrogen in the pig iron occurred and this agrees with results of other investigators.

In conclusion, this new process of desulphurization, using high concentrations of lime in the gas, pro-

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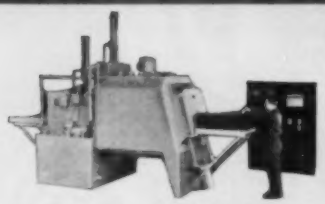
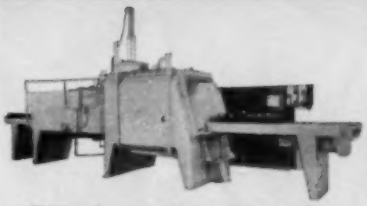


This Ipsen T-400 Automatic Atmosphere-Controlled Unit is the most versatile of all units.



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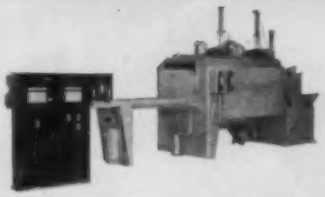

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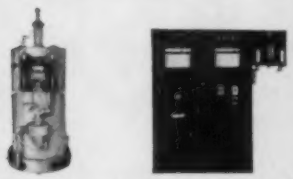

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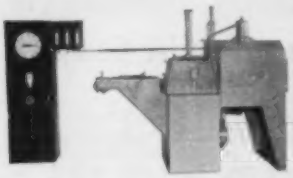
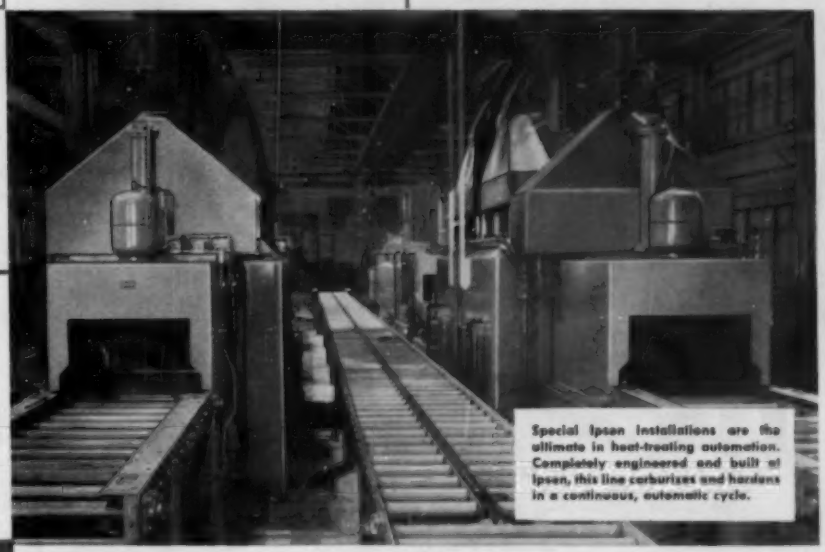


The RT-25-E permits controlled-atmosphere heat treating in the laboratory or tool room.



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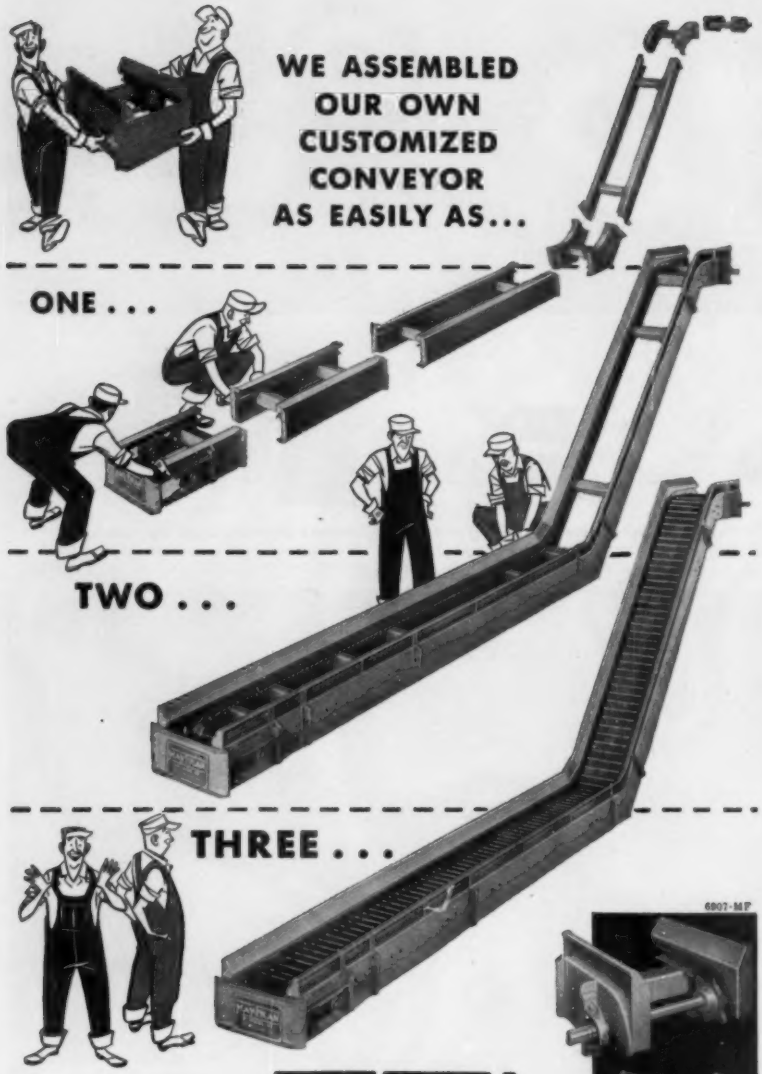

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## Desulphurization . . .

duces extremely effective conditions of contact between the desulphurizing agent and the liquid pig iron because of the immersed tuyeres.

Using nitrogen and adopting necessary precautions against the introduction of foreign slags, the process enables rapid and efficient desulphurization of the melt to be carried out, so that low residual sulphur contents (less than 0.10%) can be attained in a few minutes.

The addition to the lime of strong reducing agents such as aluminum facilitates the attainment of very low sulphur contents (less than 0.004%).

The effectiveness and the speed of this process, using inexpensive materials, enables it to be applied to varied desulphurization problems. It can be used either in foundries for ordinary pig iron or special (nodular) iron, or in integrated iron and steelworks where the increasing amounts of sulphur now coming in are creating considerable technical and economic problems.

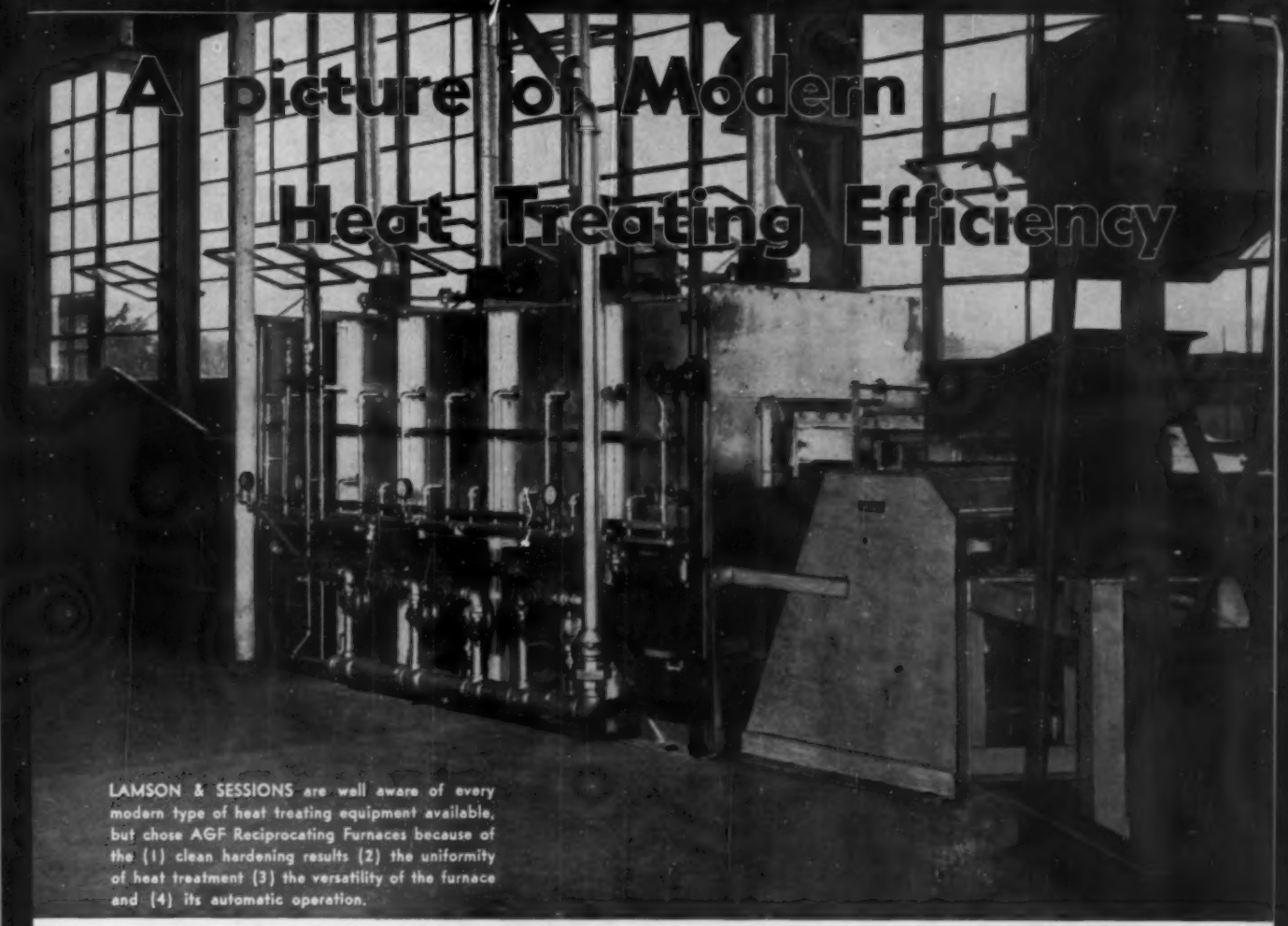
E. C. WRIGHT

## Copper Infiltration of Iron Powder Compacts

Digest of "Characteristics of Copper-Infiltrated Porous Iron", by J. E. Elliott, *Metallurgia*, Vol. 52, November 1955, p. 226-234.

THE STRENGTH of cold pressed and sintered metal powders of somewhat porous nature is impaired by the stress-raising action of the pores as well as by the metal in them. These pores can be filled by the process known as infiltration but the infiltrant must wet the skeleton metal and be virtually insoluble so that no new alloy phases are formed. The cost of infiltration of iron compacts with copper is relatively low. Better properties can be achieved after heat treatment.

A study of the copper-iron phase diagram shows that the equilibrium conditions at 1970° F. are represented by the liquid phase containing 2.3% iron and the solid phase containing 8% copper. As the temperature increases, the solubilities of both become greater and no inter-

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## Infiltration . . .

metallic compounds are formed.

Infiltration was accomplished by heating sintered iron powder compacts with compacted copper for ten min. at 2000° F. in an exothermic atmosphere of burnt city gas. A sufficient amount of copper was used to fill about 90% of the calculated pore volume. The infiltrated blank showed deep erosion of the top surface where iron had dissolved into the molten copper.

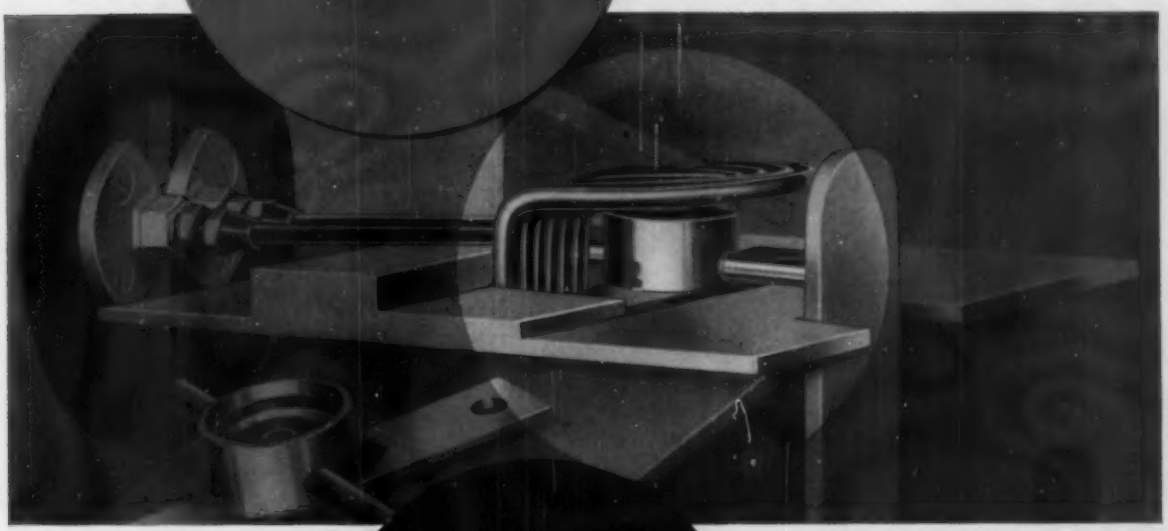
At 2000° F. 2.43% of iron can be dissolved in copper. Infiltration does not mar the surface of the compact when a cast slug of 2.43% iron alloy is substituted for the pure copper. Erosion marks are left for the same alloy at 2075° F. or for an alloy containing slightly less than 2.43% iron at 2000° F. Infiltration with alloys containing excess iron left adherent metallic deposits on the surfaces of the compacts. Pre-alloyed copper-iron powder can be substituted for the cast slugs. Infiltrant compacts of mixed copper and iron powders eroded the surface lightly and left a slight iron deposit. A good surface finish can be produced if the mixed compacts are presintered at 1920° F. for 30 min.

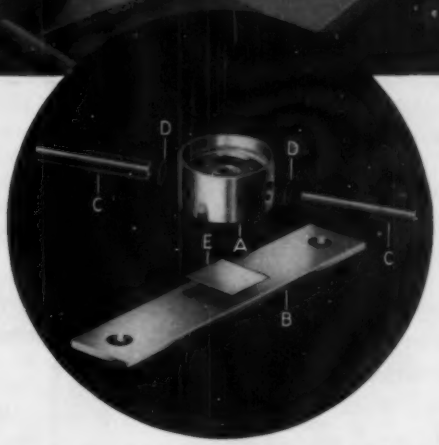
All copper-iron alloys must be infiltrated at some fixed temperature to avoid surface defects. Pre-alloyed powder compacts containing 90% Cu, 5% Fe and 5% Mn were infiltrated into iron compacts at 1985 to 2000° F. There was no erosion or adherent deposits whether the compacts were sintered in exothermic gas, cracked ammonia, or cylinder hydrogen. The oxide deposits left were loose and slightly magnetic. Although the deposits were largely copper, they contained 98% of the manganese when the compacts were sintered in exothermic gas. For more reducing atmospheres, up to 30% of the manganese was absorbed. Addition of manganese to the infiltrant enabled a good surface finish to be produced even though there was a lower infiltrating efficiency (10 to 20%) and a wider range of temperatures.

At 2020° F. 8% copper can be absorbed in the solid iron skeleton. The rate of solution of copper in solid iron is lower than that of iron in liquid copper.

Solid iron-copper alloys increase

# PHOSON SIMULTANEOUSLY BRAZES 3 GAS-TIGHT JOINTS IN 60 SECONDS






*Assembly in position for induction brazing, and fully brazed assembly in slide off cooling position.*

This bypass valve, for use with a telephone cable pressurization program, was designed for *strength, gas-tightness, corrosion resistance, long life* and *mass production.*

Here's what the problem involved: a brass machined hub (a) had to be fastened to a plate (b) and two copper tubes (c) fastened to the hub. Because the finished joints had to embody all the requirements of the base materials, low temperature brazing with Phoson and Sil-Flux was chosen. Two Phoson rings (d) ¼" ID x .031 wire and a Phoson shim (e) ¾" square x .003 were specified. By induction brazing with Phoson and Sil-Flux, the four parts were joined simultaneously in just 60 seconds!

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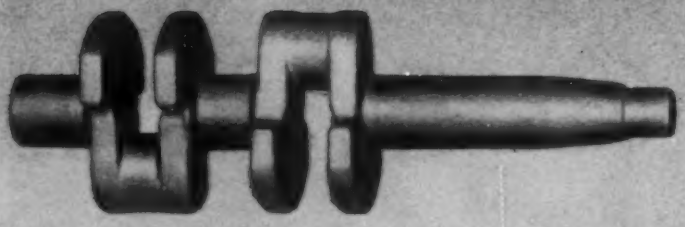

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**Make it a point to call in a forging engineer to learn more about how up-to-date methods and techniques of forging can help to reduce your products or part cost.**

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## Infiltration . . .

in strength and decrease in ductility as the copper content increases from 0 to 8%. Forging accentuates these tendencies. A hardness of Brinell 80 to 83 was developed in iron compacts sintered in exothermic gas and infiltrated with copper for 10 min. at 2020° F. Specimens were solution heat treated for 30 min. at 1445, 1625 and 1920° F. and quenched in water. One specimen was furnace cooled from 1920° F. while the remainder were air cooled. The quenched specimens were aged at 900° F. With the exception of the furnace cooled specimen, the Brinell hardness was about 124. Aging decreased this hardness slightly. No other treatment produced greater hardness.

Compacts cooled in the furnace increased in strength slightly and decreased in elongation as the soaking period at 2020° F. was extended from 10 to 30 min. Reheating compacts (previously infiltrated at 2020° F. for 10 min.) to 1625° F. for 30 min. followed by air cooling had a much greater effect. Several compacts treated to a Brinell hardness of 92 had an ultimate strength of 55,500 psi. and 1.5% elongation.

The ductility of infiltrated compacts made of pure iron skeletons was increased by presintering. A maximum strength of 79,500 psi. was obtained for compacts presintered at 2020° F. for 20 min. The strength was further increased (to 85,000 psi.) by presintering the skeletons of pre-alloyed 92% Cu, 8% Fe powder the same amount. The infiltrant filled the pores completely although some blind pores remained empty in all compacts.

Strength and ductility both were increased by presintering the skeleton to increase the weld area beween particles. Strength was increased and ductility was decreased by diffusion of copper into solid iron. Wide weld areas decreased the degree of diffusion.

A skeleton of coarse powdered iron presintered to a high degree and infiltrated for the shortest possible time produced a compact with the least alloyed copper and highest ductility. The slowest rate of cooling from the infiltration temperature proved most desirable.

WEBSTER HODGE

# How to make your automatic heat-treating and hardening even more automatic

## ...at no extra cost

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You can get the utmost in uniformity, and automatic operation—at no extra cost—by using Timken® fine alloy steel. Uniformity is constant from bar to bar, heat to heat, order to order.

We take many extra quality-control steps to assure this uniformity. For example, the Timken Company uses a magnetic stirrer for molten steel to assure equal distribution of alloys, uniform temperature and improved working of the slag. It's the first installation of its type in the United States.

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To make your automatic heat-treating and hardening operations even *more* automatic—at no extra cost—always specify Timken fine alloy steel. You'll get money-saving performance and uniform results every time. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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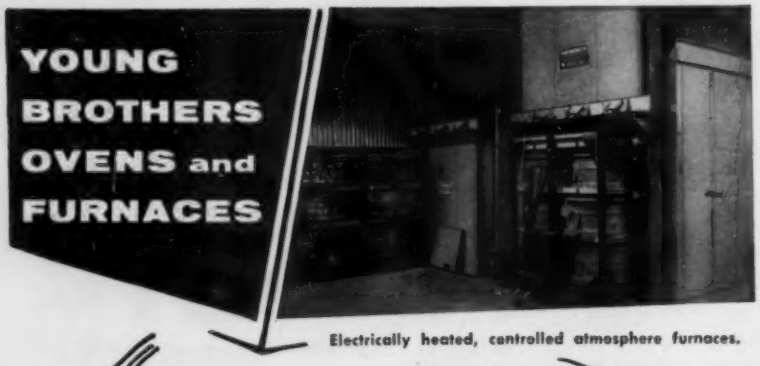
# Bainitic Retained Austenite

Digest of "Bainitic Retained Austenite", by J. A. Cameron, *Journal* of the Iron and Steel Institute, Vol. 183, July 1956, p. 244-253.

IN THE BAINITE REACTION in carbon and alloy steels, partial transformation of austenite in the bainite range lowers the $M_s$ of the untransformed austenite and increases the amount of austenite retained at room temperature. The name "bainitic retained austenite" has been used to describe the austenite retained upon slow cooling through the bainite range because no retained austenite is obtained when the same steels are water quenched from the austenitizing temperature. The present paper does not deal with the theory of the retention of austenite, but does deal with the conditioning of the retained austenite so that it may transform during or upon cooling from a tempering treatment. The main method used in the present study was dilatometric supplemented by X-ray, hardness, microstructure and microchemical data.

Previously reported data, deduced from X-ray measurements of lattice parameter changes on a 0.4% C steel, show that the carbon content of the retained austenite increased to about 1.2% C as bainite formation proceeded, although only 0.4% C was present in the parent austenite. While the mechanism of the bainite reaction is not known, at least one of the theories of bainite formation by nucleation and growth predicts that carbon concentration gradients in austenite control the growth of bainite. However, it is not obvious why the bainite thus grown does not have the carbon content of the parent phase but supersaturates the austenite so that it can be retained at room temperature. Some electron microscope measurements have shown that carbon enrichment is highly localized around each plate; however, other measurements on hypereutectoid steels show no enrichment at all.

The term "conditioning" has been used frequently with reference to the retained austenite occurring in tool-steels. Double and triple tempering are associated with conditioning the retained austenite so that it will decompose upon cooling from the tempering temperature. The present study was undertaken to investigate what tempering treatments would permit conditioning so that part or all of the retained austenite would decompose upon cooling from the tempering temperature. Throughout the work, a basic electric steel having 0.41 C, 0.29 Si, 0.63 Mn, 0.006 S, 0.011 P, 0.24 Ni, 3.43 Cr, 0.97 Mo and 0.20 V was used. The austenitizing treatment was 30 min. at 940° C (1720° F.), and this developed an austenite grain size of A.S.T.M. No. 8. The first series of dilatation tests was performed to determine the stability of the bainitic retained austenite on tempering as a function of the temperature at which bainite formation was arrested during cooling at 5° C. (9° F.) per hr. The dilatometer specimens were austenitized in closed cylinders to prevent scaling and were cooled in air (no pearlite reaction) to 550° C. (1020° F.). They were then cooled at 5° C. per hr. to 340, 325 and 310° C. (640, 620 and 590° F.) and quenched in water. Another sample was allowed to cool continuously to 20° C. (70° F.). Hardness of the resulting structure varied from Vickers 549 for the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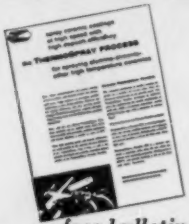

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## Austenite . . .

sample water quenched from 340° C. to Vickers 465 for the sample slow cooled to 20° C., but the amount of retained austenite was nearly the same in all samples – about 20 to 25%. All samples were tempered in a lead bath at 555° C. (1030° F.) for 2¾ hr. and dilatation-temperature curves were obtained while heating, holding and cooling in air during the course of the tempering treatment.

After tempering, the hardness of the samples was in the range of Vickers 500 to 540 and only 5% retained austenite remained. The authors do not mention the type of dilatation curve they found upon heating but do report that no dilatation occurred upon holding at 555° C. (1030° F.).

A second series of tests was carried out to find the effects of tempering time and temperature. All initial samples were austenitized as before and treated to give a hardness of Vickers 465, and 25% retained austenite. Conditioning at 460° C. (860° F.) allowed 10% of the retained austenite to remain after 70 hr. at temperature. At 550° C. (1020° F.), the amount of retained austenite was reduced to about 5% in somewhat less than 2 hr. However, in tests for only 15 min., about 10 to 15% austenite was retained and lattice parameter measurements indicated an austenite carbon content of 0.6% instead of the original 1.2%. At 635° C. (1170° F.), the specimens began to expand after 45 min. at temperature, indicating isothermal austenite breakdown. Any austenite which did not transform isothermally reacted on cooling so that the reaction was essentially complete.

The last series of tests was undertaken to show how tempering would proceed on samples cooled slowly through the bainite range and then reheated immediately to the tempering temperature. This technique eliminated the water quench after the austenite-to-bainite reaction. No significant differences were observed between the water quenched and slowly cooled samples. Finally, the results of tensile tests showed that the transformation of retained austenite after tempering moderately increased the tensile strength of the steel used in this study.

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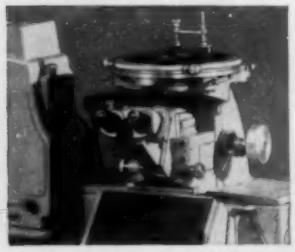

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# Effect of Fatigue and Corrosion Fatigue on Al-Cu-Mg-Zn Alloy

**Digest of "Some Microscopical Observations on the Effect of Fatigue and Corrosion Fatigue Stresses on D. T. D. 683", by C. A. Stubbington and P. J. E. Forsyth, Royal Aircraft Establishment, Farnborough, Technical Note No. Met. 211, February 1955, 11 p.**

A HIGH-STRENGTH ALLOY of the type D. T. D. 683, an aluminum-copper-magnesium-zinc alloy, often failed prematurely in service and the fatigue fracture showed signs of associated intercrystalline cracking. Earlier work showed that aluminum with 10% zinc and other simple alloys failed by intercrystalline cracking. This occurred when the alloys were subjected to fatigue stresses at room and elevated temperatures respectively due to boundary precipitation in a zone of depleted solute atoms.

The D. T. D. 683 consisted of extruded bar 0.75 in. diameter and the specimens were designated as follows: Type A specimen – the bar was hot forged, annealed and cold rolled to specimen thickness of 0.025 in., producing recrystallized and equi-axed grains at the solution treatment temperatures used in the investigation. Type B specimen was cut longitudinally from the center of the 0.75-in. diameter bar, retaining the "as extruded" structure.

Type A specimens solution treated at 870° F., quenched in water and immediately fatigued, showed transcrystalline failure generally following crystallographic directions, and exudation of metal from slip bands. When the same type of heat treated specimen was fatigued at various temperatures up to 570° F. for 100,000 cycles, representing a time order of 10 to 15 min., the thickness of the slip band exudations was observed to increase, eventually producing a "block" type extrusion at 390° F. Transcrystalline failure was produced in the room-temperature and elevated-temperature test specimens.

With Type A specimens solution treated between 750° F. and 970° F., water quenched, and immediately fatigued, slip band extrusion decreased markedly at solution treatment temperatures above 870° F.

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## Fatigue . . .

and was not observed at 970° F. Again transcrystalline fatigue failure resulted in all specimens.

Specimens overheated at 1010° F. to produce liquation at the grain boundaries, water quenched and immediately fatigued, still produced transcrystalline failure with absence of slip band exudation. In no instance was the fatigue crack observed to follow the boundaries where liquation had occurred.

Tests were carried out on both Type A and B specimens to determine the effect of time at aging temperature on fatigue behavior. Specimens solution treated at 870° F. for 16 hr. were quenched in water. Individual specimens were aged at times ranging from 1 hr. to 12 days at 265° F. In all the aged conditions investigated, transcrystalline fatigue failures were obtained, although after aging the Type B specimen for 12 days at 265° F. there were signs of deformation at the boundaries.

Corrosion fatigue tests at room temperature on Type B specimens solution treated at 870° F. for 16 hr., and aged from zero hours to 12 days at 265° F. showed some evidence of intercrystalline cracking after aging for 1 hr. More extensive regions of intercrystalline cracking appeared after aging from 2¾ to 6 hr., although the main failure was still transcrystalline. With longer aging times the amount of intercrystalline cracking was found to decrease.

The effect of solution temperature in the range 750 to 970° F. was investigated as a cause of intercrystalline cracking during corrosion fatigue at room temperature. It was found that the corrosion fatigue failure produced on the specimen treated at 750° F. was transcrystalline in the region of maximum stress, with patches of intercrystalline cracking in regions remote from the zone of maximum stress. Solution treatment in the range 790 to 970° F. gave failures that were wholly intercrystalline.

The fatigue failure produced when D. T. D. 683 was fatigued in air in the solution treated condition was similar to that produced on simple binary alloys of the age hardening type. The failure was characterized by transcrystalline cracking and slip band exudation. In contrast to the binary alloys, the more complex alloys showed some slip band exudation when fatigued at room temperature in the fully aged condition.

The failures obtained when the extruded material was subjected to corrosion fatigue in certain aged conditions were very similar to those observed on some service fatigue failures. They exhibited patches of intercrystalline cracking joined by transcrystalline cracks. The experiments indicated that poor corrosion fatigue properties would be obtained with short aging times at 265° F. whereas in an extended time-aged condition the properties would be relatively good. It would appear that the longer aging times do not produce a high susceptibility to intercrystalline cracking under conditions of corrosion fatigue and in this condition there is a visible and marked precipitation at the mosaic


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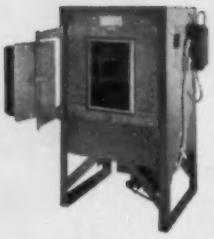

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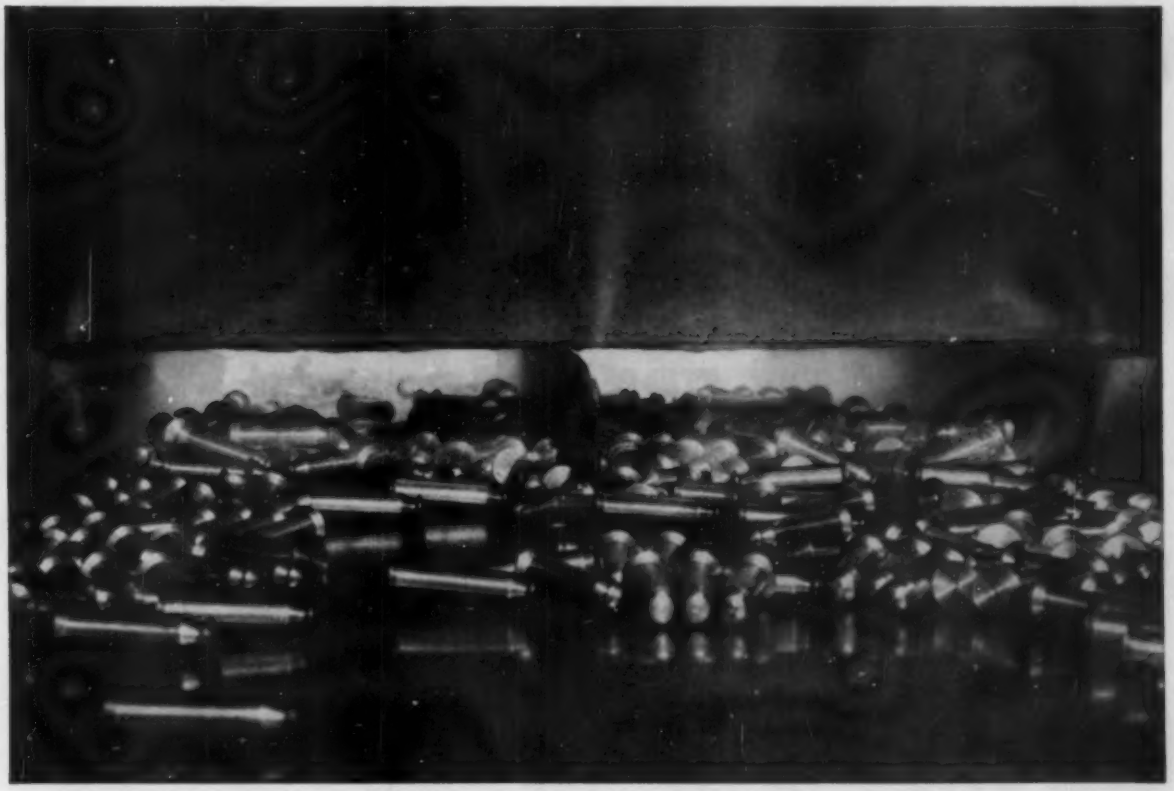

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## Fatigue . . .

boundaries. At short aging times, which show maximum susceptibility to intercrystalline cracking, it is suggested that there is either a continuous film of anodic precipitation or a high degree of ordering, leading to a concentration of solute atoms at the mosaic boundaries. Longer aging produces discrete anodic particles in areas of depleted solid solution and this latter condition is considered to be less dangerous than a thin continuous anodic film.

The investigation suggests that corrosion is an operative factor in many service failures of D. T. D. 683. Atmospheric moisture appears to be an effective corrosive agent.

It is suggested that a heat treatment could be evolved which would tend to improve the service life of D. T. D. 683. This would probably involve longer aging times using the specified solution temperature, or maintaining the specified aging time and temperature and using lower solution temperatures or slow rates of cooling. This assumes that the specified mechanical properties can be attained by such variations.

G. W. Brock

## Eliminating Blowholes in Cast Iron

Digest of "Sub-Surface Blowholes in Grey Irons and Their Association With Manganese Sulphide Segregation", by W. G. Tonks, *Journal of Research and Development*, British Cast Iron Research Assoc., Vol. 6, June 1956, p. 214-225.

SMALL BLOWHOLES beneath the surface of castings are especially objectionable because the worthlessness of such castings is not recognized until after costly cleaning, machining or other finishing operations have been performed. The cause of these subsurface defects in gray iron, as distinguished from gross blowholes and gas holes produced by hydrogen in the metal or by other gases arising from molds or cores, has not been clearly explained. They have, however, been more prevalent when there was more than 0.9% Mn in the iron.

The experimental work was carried out on 11 heats of gray iron

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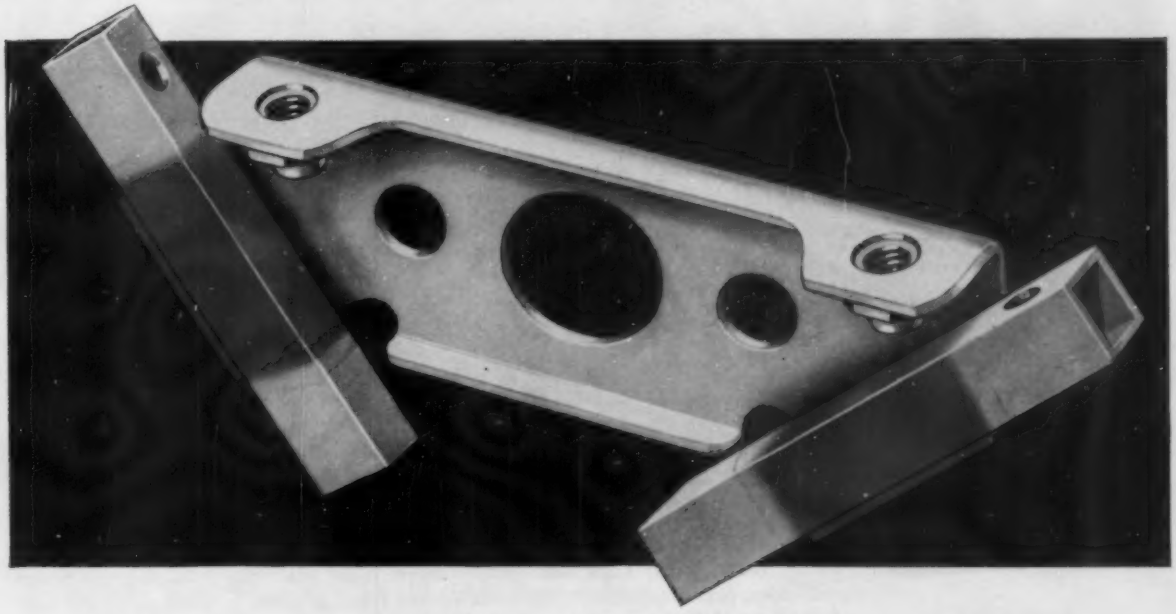

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## Cast Iron . . .

with a range of sulphur contents between 0.009 and 0.150%, all melted below 2550° F. in an oil-fired furnace with a plumbago crucible and ladles. These irons contained 2.73 to 3.26% C, 1.85 to 2.58% Si, and 0.60 to 1.14% P. Each heat was divided into five taps of three castings each and manganese was added in the furnace between ladles. The temperature was allowed to drop between castings. Thus, 165 castings were provided with variations in sulphur content, manganese content and casting temperature. The manganese content of the original melts ranged from 0.14% with low sulphur to 0.54% with higher sulphur, and in each melt it was raised in five stages to a maximum between 0.84 and 1.33%. The pouring temperatures varied from about 2460° F. for the first casting of each tap to about 2200° F. for the last.

All the test castings were hollow 4-in. cubes, gated at the bottom and cast in green sand molds with a baked core. The sidewalls were ¾ in. thick and the top 1½ in. thick. The top surface was machined off to a depth of 0.04 to 0.10 in. to reveal subsurface blowholes.

In the 0.145% S heat, all the castings poured at 2190° F. had blowholes, but the two cast at 2460° F., which contained less than 0.7% Mn, did not. The ladle slag was found to increase in manganese and sulphur as the temperature fell. In the heats containing 0.11 and 0.088% S, the blowholes were again found in the castings poured at about 2200° F. and in the higher-manganese castings poured hotter. Segregated manganese sulphide was associated with the defects. In the 0.057% S heat, the defects found in the castings poured colder were called "blemishes" instead of blowholes, and manganese sulphide segregations were not found near them.

At temperatures below 2425° F., slag could be seen rising to the surface of metal in these ladles, especially with the higher manganese contents. It formed a fine pattern at first which became coarser as the temperature fell and finally changed to a continuous film.

Manganese sulphide forms in molten cast iron from the reaction of manganese with iron sulphide,

# Tool Steel Topics

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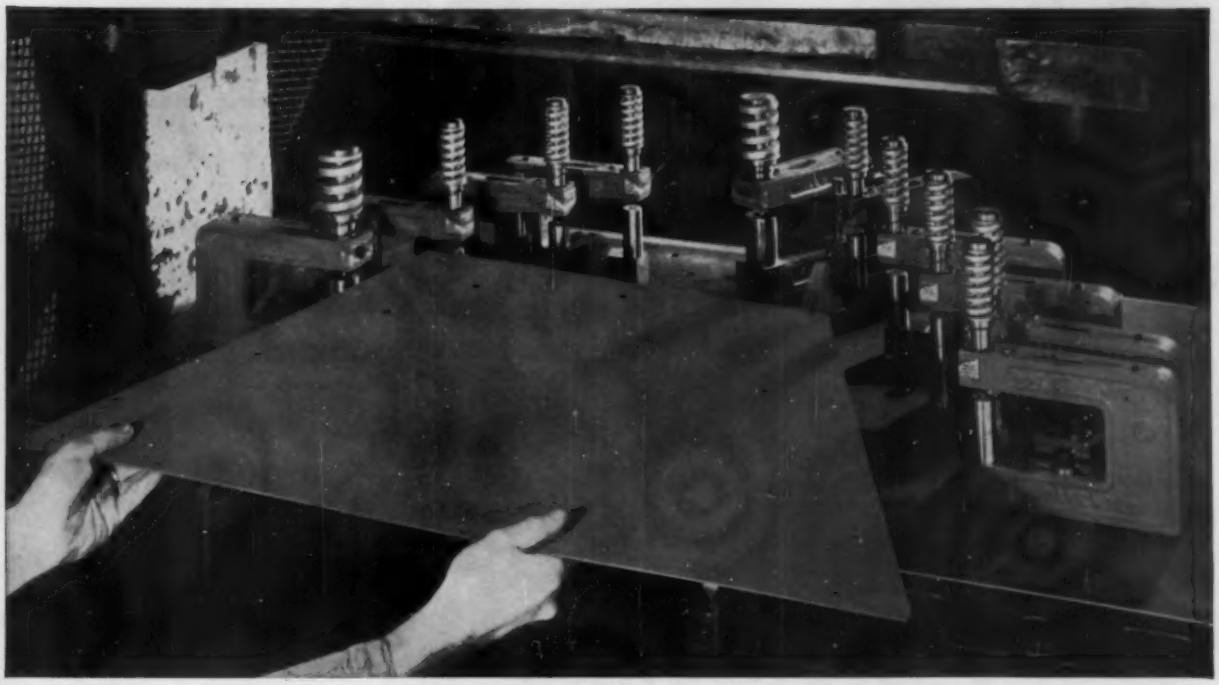

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If you'd like to see some interesting metal-punching jobs, the place to visit is Wales-Strippit Company, at North Tonawanda, N. Y. There they employ about every punching operation imaginable, using self-contained punching units which are set up quickly to meet the requirements for varied hole sizes or shapes.

One of the tool steel grades which has been doing a fine job of minimizing shop costs at Wales-Strippit Company is Bethlehem Omega, a super-tough steel supplied by Leed Steel Co., Buffalo. Omega's dependability and long service life have been remarkable . . . all the more so because it is used exclusively in punching hard metals, where high shock-resistance heads the list of requirements.

Omega is our "super" grade of oil-hardening, shock-resisting tool steel. It can also be quenched in water. Here's its typical analysis:

| C | Mn | Si | Mo | Va |
|---|---|---|---|---|
| 0.60 | 0.70 | 1.85 | 0.45 | 0.25 |

Omega isn't limited to service in punches, either. It's just what the doctor ordered for hand and pneumatic chipping chisels, knockout pins, swaging dies, shear blades, and other uses where the steel is continually subjected to severe shock.

## Making Plastic Parts? Use Lustre-Die

Lustre-Die, our new plastic-molding tool steel, is really something! What a high polish it takes! And what high lustre you get on the finished parts! Lustre-Die has a well-balanced analysis, and is alloy fortified to increase its depth of hardenability and mechanical properties. It's good steel. You'll like it.

## BETHLEHEM TOOL STEEL ENGINEER SAYS:

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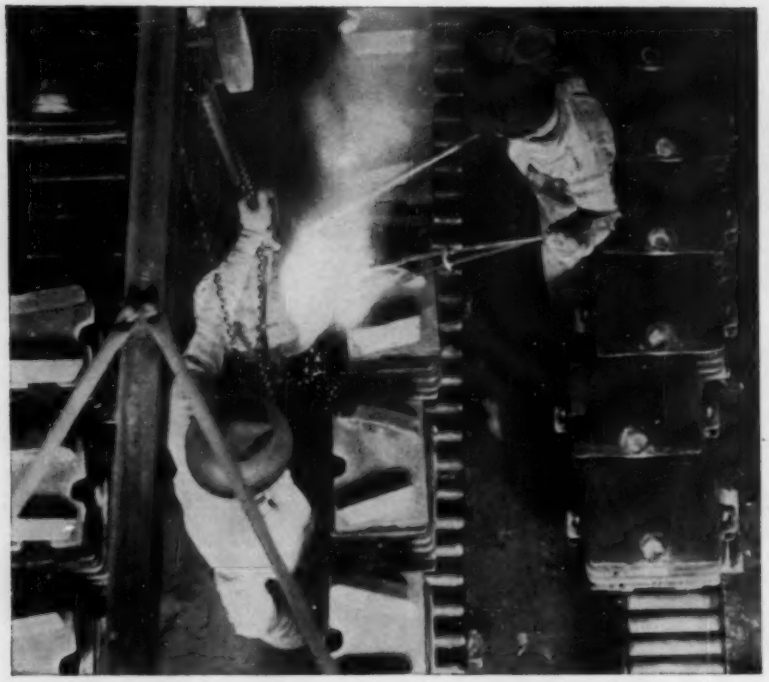
Most users of hot-work steels know that the oxide skin, put on the surface of tools by the second temper, is beneficial. This oxide coating serves partly as a lubricant, and also helps conventional lubricants to adhere, thus increasing wear-resistance.

When tempers above 900 F are used, Lehigh H tool steel is also benefited in the same way by the oxide coating resulting from the second temper. Here is the sequence of operations to be followed in heat-treating Lehigh H, so as to take advantage of the oxide coating:

1. Heat the tool and quench it in the conventional manner.
2. Temper at 925 F (or higher for some purposes).
3. Grind the tool to size, and remove scale and decarburization.
4. Retemper the tool at 900 F. Do not grind or remove the light oxide coating—use the tool with this surface.

# Have you had trouble with Engineered Bronzes?



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## Cast Iron . . .

and as the melt cools, the manganese sulphide starts to precipitate at higher temperature as the manganese content increases. When the product of manganese content times sulphur content exceeds a certain value "K" for a given temperature, manganese sulphide segregates in the liquid and subsurface blowholes occur in the castings. At higher pouring temperatures, the product of manganese content times sulphur content, above which blowholes occur, is raised and with lower temperatures, it is lowered.

Most cupola-melted iron (in England) contains 0.08 to 0.14% S, and the manganese should be less than about 0.54% to avoid subsurface blowholes. Pouring temperatures should be high to prevent segregation of manganese sulphide in the melt and to facilitate the evolution of gases. The ladles should be clean so that slag accumulations do not contaminate the metal. The manner in which sulphide and slag segregations in the molten iron produce subsurface blowholes is not discussed. The primary factor promoting these defects is a low pouring temperature, but high sulphur and manganese contents are contributing factors.

G. F. COMSTOCK

## Tempering and Nitriding of 3% Cr Steels

Digest of "The Tempering and Nitriding of Some 3% Chromium Steels", by C. C. Hodgson and H. G. Baron, *Journal* of the Iron and Steel Institute, Vol. 182, March 1956, p. 256-265.

THE HARDNESS obtained by nitriding medium-carbon chromium-aluminum steels was shown to be virtually independent of prenitriding hardness and tempering temperature. This gave rise to the belief that the case hardness obtained by nitriding was affected only by the composition of the steel. This belief was proven erroneous so an investigation was begun to determine the influence of various factors such as tempering temperature, tempering time, and carbon content on the response to nitriding of steels which

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## Nitriding . . .

differed only in carbon content. The steels investigated were of a 3% Cr, 0.5% Mo type with carbon contents ranging from 0.10% to 0.36% and vanadium from 0% to 0.41%.

Each steel was cast in the form of 100-lb. ingots, forged into bars 1¼ in. in diameter and normalized at 1740° F. A medium-manganese steel, included for comparison, was furnished as a 1-in. diameter bar.

Thirty-six disks ¾ in. thick were cut from each steel, heated to 1650° F. in a neutral salt bath for 1 hr. and quenched, the chromium steels in oil and the manganese steel in water. Hardness readings were taken on two samples of each steel and then all the disks were tempered. The tempering temperatures ranged from 930 to 1290° F. in 45° increments. The tempering times were 6 min., 1.3 hr., 10 hr. and 100 hr. with actual times at temperature of 4.5 min., 1.0 hr., 9.7 hr .and 99.7 hr. All specimens were air cooled after tempering.

Hardness readings were then taken and plotted against tempering temperature. The curves revealed two regions of retarded softening for the higher carbon Cr-Mo steels. It was concluded that the first retardation took place when the percentage of chromium in the cementite was small and the second occurred when $Cr_7C_3$ was formed. The addition of vanadium tended to bridge the gap between the two regions and provided a more uniform softening rate.

All specimens were nitrided for 72 hr. at 930° F. Hardness readings were again taken and depth-hardness curves were drawn. A careful study of these curves gave rise to the following conclusions:

1. The maximum case hardness and case depth were inversely proportional to the previous tempering time or temperature.

2. The magnitude of this effect was dependent upon the carbon content, being quite large in steels with more than 0.3% C except when very long tempering times were used.

3. The hardness increase resulting from nitriding is approximately a linear function of the core hardness.

4. The response to nitriding is poor when the chromium in the steel is segregated in the carbides.

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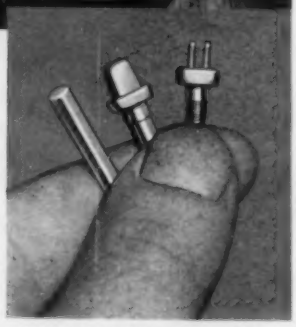
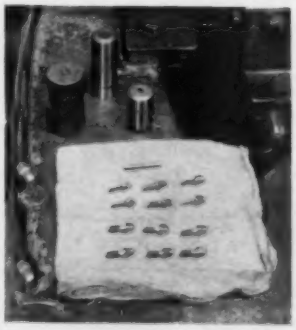
The result—terminal screws produced by cold heading process instead of milling—at very substantial increases in production and much lower cost.

Vulcan representatives *like* tough problems. They welcome highly-demanding tests of Vulcan tool steel superiority. They enjoy tackling a variety of problems, because Vulcan's complete line of fine quality tool steels allows them to give *right answers*—not "almost as good" recommendations.

A representative is nearby to serve you. *Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.*



VULCAN Special Vanadium used for cold heading dies that are tough enough to produce slotted Nickel terminal screws at H. M. Harper Company, Morton Grove, Illinois.



HKP VULCAN CRUCIBLE STEEL DIVISION
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# Study of Electric Furnace Electrode Consumption

**Digest of "Factors Affecting Electrode Consumption in Electric Arc Furnace", by D. H. Houseman, *Journal* of Iron and Steel Institute, Vol. 183, May 1956, p. 48-53.**

THIS PAPER describes a statistical study of electrode consumption in two 5-ton arc furnaces of 3500 kva. in a steel foundry. The electrodes used were 10-in. diameter graphite. The study covered a full year. Measurements of bulk density and resistivity of the electrodes were correlated with rate of electrode consumption.

Records of electrode consumption in the plant for the years 1952-54 indicate wide variations from 11.5 to 17 lb. per ton of steel. At present prices in the United States for graphite electrodes, this variation of 5.5 lb. per ton amounts to $1.50 per ton of steel.

Graphite nipples, having special steel terminals in their end faces, were screwed into the end of each electrode under test. The circuit was completed using a rheostat to adjust the current to an accurately known value between 10 and 12 amp. The potential drop was measured using a portable potentiometer. Three determinations of potential drop were made along the length of each electrode at constant current input. The mean value of these determinations was referred to as the "mean resistivity" of the particular electrode.

Next, the bulk density of each electrode was computed. A total of 498 10-in. diameter electrodes were examined.

Wide variations in mean resistivity were found. Striking differences in resistances at end and mid-point sections of individual electrodes were also discovered. The spread amounted to 800 to 1537 microhms per sq.cm. in mean resistivity and differences of as much as 400 microhms in individual lengths. The bulk density varied from 1.525 to 1.650 g. per cc., but there was no correlation between bulk density and resistivity or electrode consumption.

During the testing of incoming batches of electrodes, those having mean resistivities in the ranges 801

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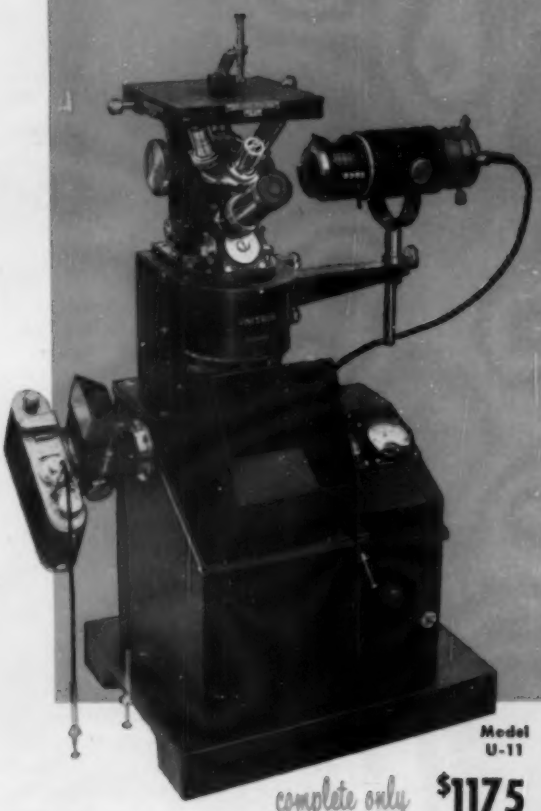

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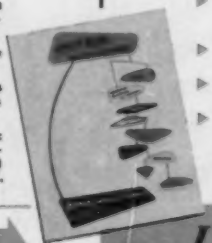

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## Electrodes . . .

to 900, 901 to 1000, 1001 to 1100, and 1101 to 1200 cm. were separated into groups for electrode consumption trials.

Each group of electrodes was used to determine the relationship of electrode consumption to tonnage of steel produced.

A study of the data indicated a highly significant correlation between resistivity and electrode consumption. To check this, seven electrodes which had resistivities greater than 1200 microhms per sq.cm. were used on one furnace. The consumption was 13.7 lb. per ton of steel — a value which matched the correlation curve. A long-time test from August to December 1954 was then made using only electrodes having a resistivity below 1000 microhms per sq.cm. The average consumption was 10.44 lb. in one furnace and 10.87 lb. in the other.

Results of the test are summed up as follows:

1. There is a direct and statistically valid relationship between electrode resistivity and consumption in the two basic arc furnaces used in the investigation.

2. Long-term trials using only electrodes of low and medium resistivity have shown that large savings are possible in electrode costs.

3. Electrodes may be sorted into standard groups, on a resistivity basis, for use in investigations of other steelmaking variables.

4. As electrode consumption decreases, power costs per ton of steel produced may rise; this rise is, however, more than offset by the fall in electrode costs so that a large net saving results from using low-resistivity electrodes.

5. While there is an inverse correlation between electrode bulk density and resistivity, the low accuracy of the correlation renders the former unsuitable for use as an acceptance test despite its simplicity.

E. C. WRIGHT


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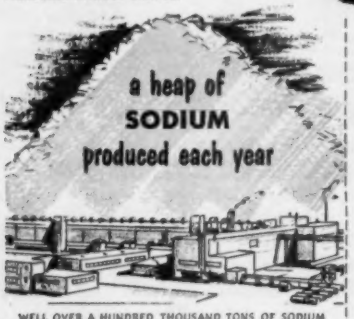


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## Welding and Brazing the Newer Metals

Digest of "Welding and Brazing Refractory Metals — Mo, Nb, Ta, Zr", by F. G. Cox, *Murex Ltd. Review*, Vol. 1, 1956, p. 429-463.

MOLYBDENUM, tantalum, columbium and zirconium are beginning to play increasingly important roles in today's fast-moving metallurgical developments. Such metals have unique and useful properties.

As the base material for high-temperature alloys, molybdenum shows great promise. Tantalum, which is resistant to most acids, has many applications in the chemical processing industry. Columbium resists corrosion and creep well at elevated temperatures. An important application of zirconium is in atomic reactor components because of its corrosion resistance and good thermonuclear properties.

The joining problems with tantalum, columbium and zirconium are comparable because their reaction with all the common gases results in a loss of ductility.

Molybdenum is almost always embrittled by welding.

Tantalum, columbium and zirconium can be welded readily in an inert atmosphere such as argon. This gas prevents the absorption by the metal of common gases present in the air. Either direct or alternating current may be used but direct current with the electrode negative is preferred. Welds using direct current and the electrode positive might become contaminated with

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## Welding . . .

tungsten from the electrode while those using alternating current are only satisfactory when a highly protective atmosphere and high current are used. Inert-arc spot welding (using argon) is useful for attaching thin to thick members and for applications where it is impossible to maintain a backup shield of inert gas. Resistance spot welding requires a protective atmosphere of inert gas and suitable precautions to prevent surface contamination by electrode materials.

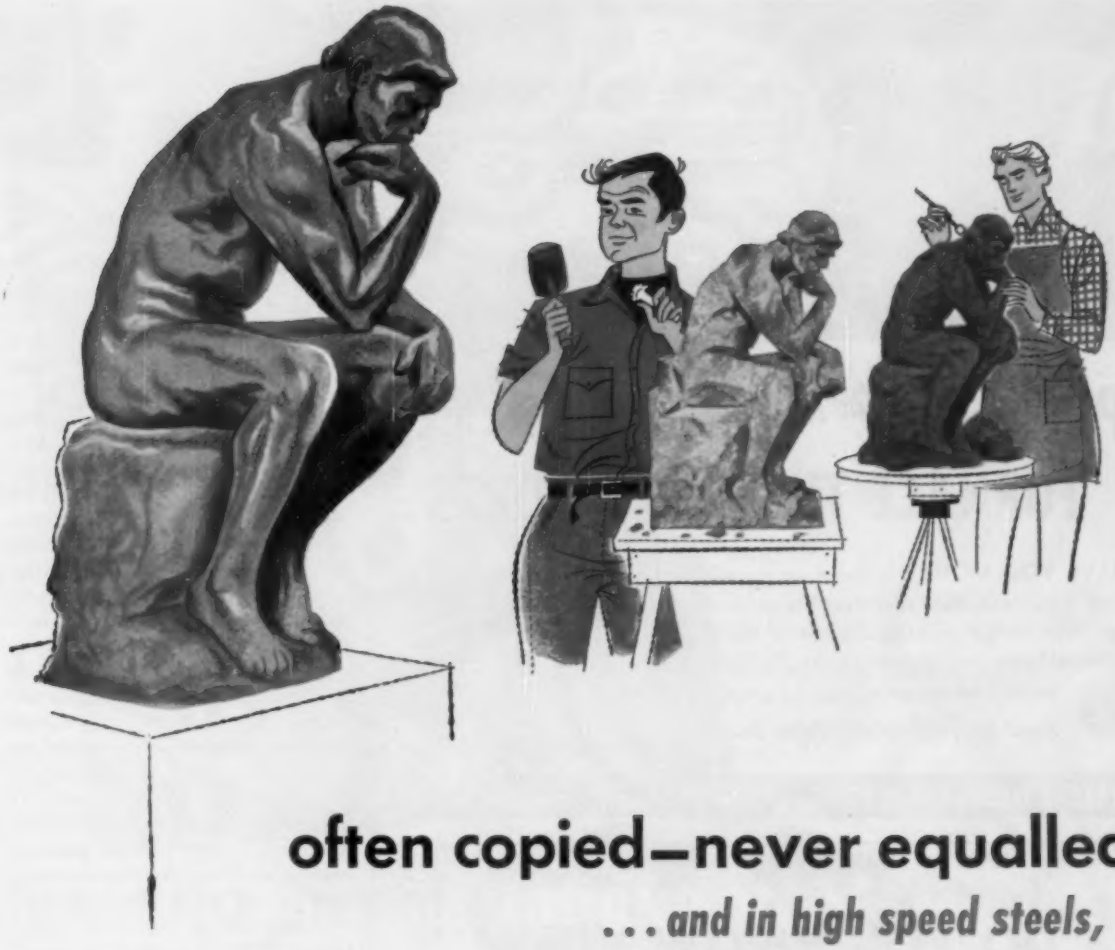
The use of filler rods is not recommended because of added contamination. Where filler rods are used the cross section of the rod must be equivalent to that of the groove so that welding can be completed in one pass. Remelting of discontinuous welds increases contamination.

The weld bead appearance of tantalum and columbium is bright and silvery and that of zirconium is discolored. The microstructure of zirconium welds shows an acicular zone attributable to a transition at 1580° F. The welds are normally as strong as the annealed base metal.

Molybdenum can be arc welded, using the same precautions outlined above. However, it is virtually impossible to weld molybdenum without producing brittle joints. If the joints are designed to reduce cooling stresses and some lack of ductility is tolerable, suitable welds can be made.

Although molybdenum has been resistance welded for some time in the electronics industry, many problems have been encountered other than joint brittleness. Electrodes and the molybdenum base metal both contaminate each other to the extent that service life of the product is short. The electrode problem can be minimized by welding under water. In instances where foreign metals can be tolerated in the joint, molybdenum is more easily welded with a shim of tantalum, zirconium or nickel between the pieces being joined.

Where maximum ductility is required molybdenum can be hot pressure welded at 1110 to 1830° F., using about 50% deformation to produce sound welds. Upset flash welding has also been used to obtain maximum ductility. However, the



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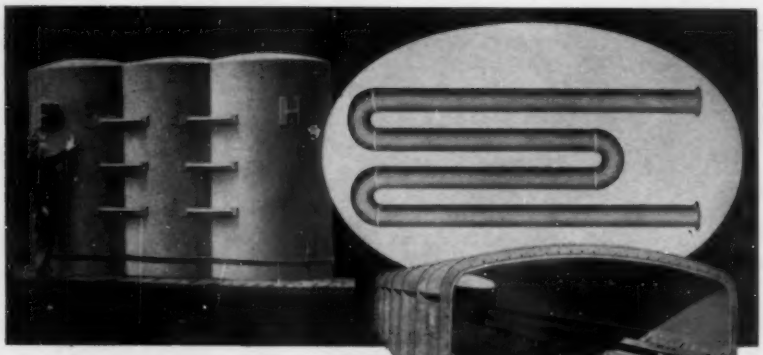

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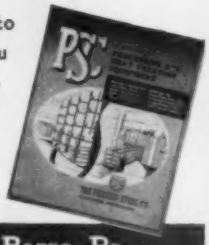

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applications where either process can be used are very limited.

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Zirconium can be brazed with pure silver and no flux by using an inert-arc torch and argon gas. The technique is difficult to control and the joints are brittle. Torch brazing with a slightly reducing flame, special flux and Sil-Fos brazing alloy produces strong but brittle joints. Again, furnace brazing in a vacuum or inert atmosphere using silver-base filler metals is useful but also produces brittle joints. The surface to be brazed is much improved by precoating the zirconium with zinc from a molten salt bath. Dipping the zirconium through a cuprous chloride flux bath also prepares the metal for subsequent brazing or soldering.

Molybdenum can be brazed by all methods since it does not form a refractory oxide. Most common brazing alloys and techniques can be used as well as such high-temperature materials as Inconel, silver-palladium alloy and molybdenum-boron alloy. With the higher-temperature brazing alloys molybdenum is recrystallized and therefore brittle.

ROBERT M. EVANS

## Micro-Examination of Creep-Test Specimens

Digest of "Kinetics of the Change in Microstructure of Metals and Alloys During Creep at High Temperatures Under Tension in Vacuum", by M. G. Lozinskii and E. I. Antipova, *Metallovedenie i Obrabotka Metallov*, 1955, No. 5, p. 9-14.

THE UNIQUE and valuable feature of this paper is four sets of twelve photographs, each taken during the course of creep tests and showing the actual changes in microstructure of structural materials. The special machine built for this research maintained a vacuum around the sheet specimen being tested. The surface of the polished specimen could

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## Creep Test . . .

then be examined microscopically while it was being heated under stress. By measuring the separation of hardness indents placed on the surface, the corresponding creep curve was obtained.

A marked difference in behavior was found between a carbon steel tested in the ferritic condition and one tested in the austenitic condition. In the ferritic steel, the polished surface was first disturbed by the gradual appearance of a network that corresponded to grain boundaries. However, at the time corresponding to the beginning of third-stage creep, slip lines and "wrinkles" became visible inside the grains. Also, when fracture finally occurred it did so along wrinkles that were approximately perpendicular to the tension axis.

In contrast to this behavior was that of a steel tested in the austenite temperature range. Although the grain boundaries were again the first structural feature that developed, they continued to increase in prominence as the creep test progressed. There was no sign of structure, such as slip lines, within the grains. Thus, the deformation of austenite occurred at the grain boundaries while the principal deformation of ferrite was within the grains.

Perhaps the above conclusion should be accepted only provisionally in view of the differences in the conditions of the two creep tests on which it is based. The steel tested in the ferritic condition contained 1.25% carbon and was tested at 1200° F. under a stress of 12,600 psi. The "austenitic" steel had 0.45% carbon and was tested at 1650° F. under a stress of 4700 psi. Since it is known that grain-boundary flow is relatively more important at high temperatures and low stresses, the observed differences might have their origin in the temperature and stress conditions rather than in the characteristics of the two phases.

Creep tests and microscopic observations were also made on nickel alloys containing 10, 20 and 40% copper. The 40% copper alloy had the smallest creep rate at 1200° F. under a stress of 9500 psi. Grain boundaries could be seen after 1.5 hr., at which time the specimen had

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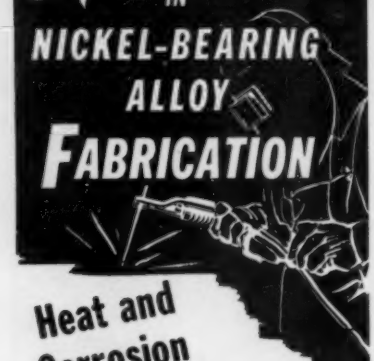

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## Creep Test . . .

elongated 0.6%. The grain boundaries became darker and eventually, after about 6 hr., cracks began to appear in them. At about the time of the first appearance of cracks, the creep rate increased markedly. The specimen failed by fracturing along the grain boundary.

A. G. Guy

## Purifying and Degassing Aluminum

Digest of "Removal of Impurities and Gases From Molten Aluminum and Its Alloys", by M. Chevigny, presented at Joint Metallurgical Societies Meeting in France, June 1955.

Impurities and gases are a major problem in the metallurgy of aluminum and its alloys. Their presence often leads to serious fabricating difficulties.

The impurities which most frequently cause trouble during fabrication are aluminum oxide, particles of cryolite, and fragments of brick or loam. It is essential that the metal be kept as free from these impurities as possible. The method of gas removal depends somewhat on the method of fabrication. In the founding of aluminum and its alloys, for example, it is only necessary to lower the gas content of the metal sufficiently to avoid pinholing or microporosity. In instances where the metal will be subsequently annealed, however, more thorough degassing is necessary to prevent the formation of blowholes when the metal is reheated.

An important characteristic of molten aluminum and its alloys is that gases can be removed more effectively after solid impurities have been removed.

The elimination of solid impurities from molten aluminum and its alloys can be accomplished by two methods, decantation and washing the metal with a flux. Decantation or the elimination of impurities by gravity separation is effective only after the metal has been held at 1470 to 1580° F. for several hours. Because of the speed that hydrogen can enter molten aluminum at these temperatures, it is advisable to keep the sur-

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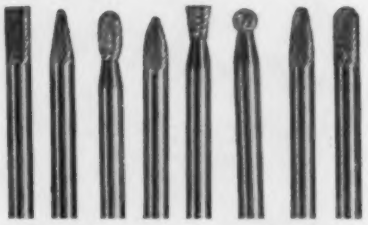

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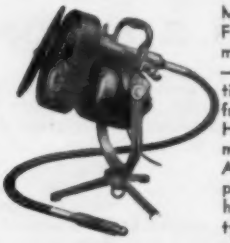

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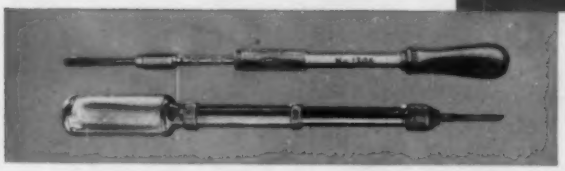

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## Aluminum . . .

face of the molten metal protected from the atmosphere with a layer of cryolite. Decantation or gravity separation has two drawbacks: It produces an enlargement of the grains in the solid metal, and it ties up equipment.

In many shops, it is preferable for the sake of speed and economy to use fluxes to accelerate the removal of impurites. The fluxes are usually mixtures of nonhygroscopic salts which are easily fusible and lighter than the bath. They often consist of different proportions of sodium chloride and potassium chloride with additions of sodium or calcium fluorides, cryolite, or chiolite. Because it is imperative that these materials be extremely dry before they are added to the molten bath, it is preferable to heat the fluxes to 300 or 400° F. immediately before using them.

Similar improvements in the quality of the metal are obtainable with gaseous fluxes which liberate chlorine or sublime at the temperatures of the bath. Additions of salt are sometimes used with hexachlorethane to slow down the decomposition of hexachlorethane and thus increase its efficiency.

Gases are eliminated from molten aluminum and its alloys by the same methods that are used to eliminate impurities. Results are almost always excellent with small quantities of metal. With larger quantities of metal, especially that used in the fabrication of plates for rolling, the elimination of gas is more uncertain.

In general, it is comparatively easy to obtain cast metal without serious pinholing. Metal of this quality will show only a few bubbles when a 300-g. sample is allowed to solidify under reduced pressures of 1 to 10 mm. mercury. In other instances, similar metal will appear satisfactory when solidified under reduced pressure, yet pinholing will occur after the metal is rolled into sheets and annealed. This latter occurrence is not clearly understood.

In a study made with 18 alloys polluted by adding damp coke to the bath at 1470° F., it was found that the gas from the damp coke was extracted from the metal far more quickly when the bath was washed with a flux before the coke treatment.


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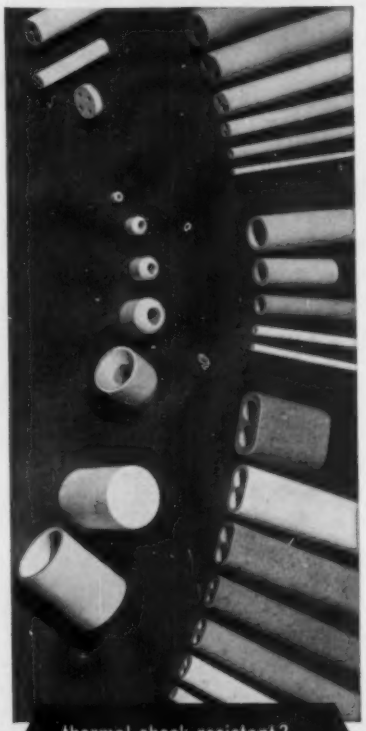


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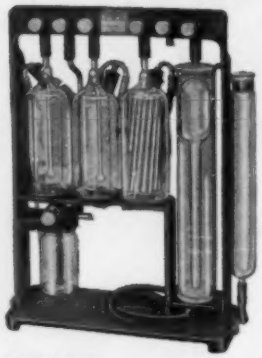

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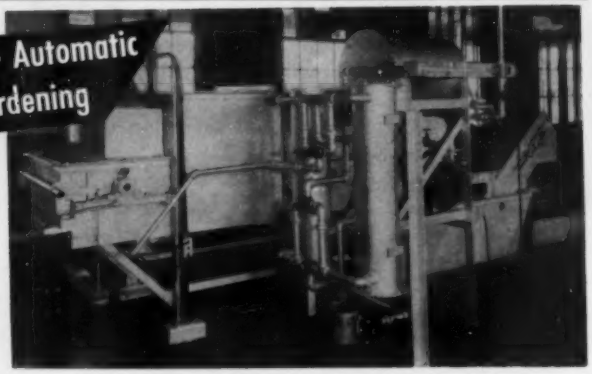


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## Aluminum . . .

The conclusion was reached that the tendency for molten aluminum to retain gas was greater when there were numerous particles suspended in the bath.

The most abundant and most difficult gas to remove from aluminum and its alloys is hydrogen. For the most part it is hydrogen that causes fabricating difficulties.

Both chlorine and nitrogen treatments will reduce the hydrogen content of molten aluminum. Chlorine seems to be more efficient, but because it is highly toxic it requires carefully designed hoods to vent the fumes. For aluminum-magnesium alloys, chlorine treatments lower the magnesium content by 0.1 to 0.2%. The use of hexachlorethane has the same effect. In addition to removing hydrogen by treating the molten metal with chlorine or other gases, remelting sometimes upgrades the metal. For best results in remelting, the metal should have previously solidified very slowly.

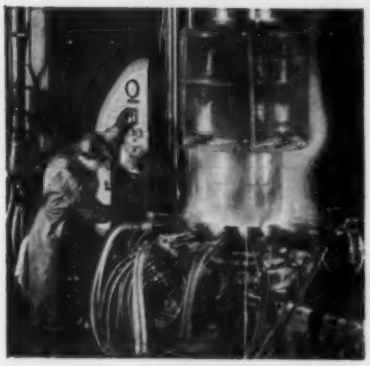
R. C. WILLIAMS

## Stress-Induced Aging in Mild Steel

Digest of "Aging Processes in Plain Carbon Steels and the Effect of Cyclic Stressing", by H. Schenck and E. Schmidtmann, *Archiv für das Eisenhüttenwesen*, Vol. 25, No. 11/12, p. 583-588.

CYCLIC STRESSING accelerates the rate of diffusion of carbon, nitrogen and chromium into steel during surface impregnation processes. In order to study the effect of cyclic stressing on diffusion and precipitation reactions in solid metals, the authors investigated the aging process in a plain carbon steel with 0.06% carbon and 0.018% nitrogen.

Preliminary experiments were carried out on the unstressed steel so that changes in tensile properties, coercivity, electrical resistance, damping capacity and microstructure could be compared at various times and temperatures of aging. The results of these measurements indicated a mechanism of quench aging. When the solid solution is quenched, there is an initial increase in tensile strength due to lattice strain. Subse-



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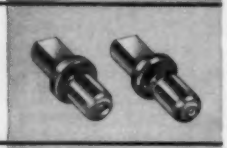

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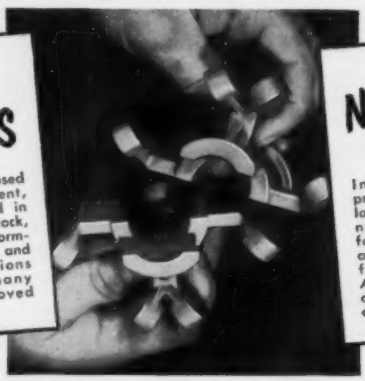

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## Aging . . .

quent aging causes an additional increase in hardness without substantial change of the concentration of carbon and nitrogen atoms in solid solution. After a prolonged period of aging or after aging above 120° F., finely divided carbide and nitride particles are precipitated and cause an increase in coercivity, a decrease in electrical resistance, a change in the damping capacity, the appearance of etch patterns and a sharpening of diffraction patterns.

The specimens used to study the effect of cyclic stressing on the aging processes were tested in a rotating-beam testing machine, in a tension-compression testing machine and by ultrasonic vibration. During testing, the specimens were cooled by an oil spray, the unstressed control specimens being maintained at the same aging temperature by placing them in the sump of the circulating oil system. With increasing stress up to the fatigue limit, the rate of aging was accelerated. Measurement of the surface temperatures of the specimens during testing was found to be not greater than 4° F. at a stress of 42,500 psi. which exceeded the maximum stress of 31,000 psi. used in the aging tests.

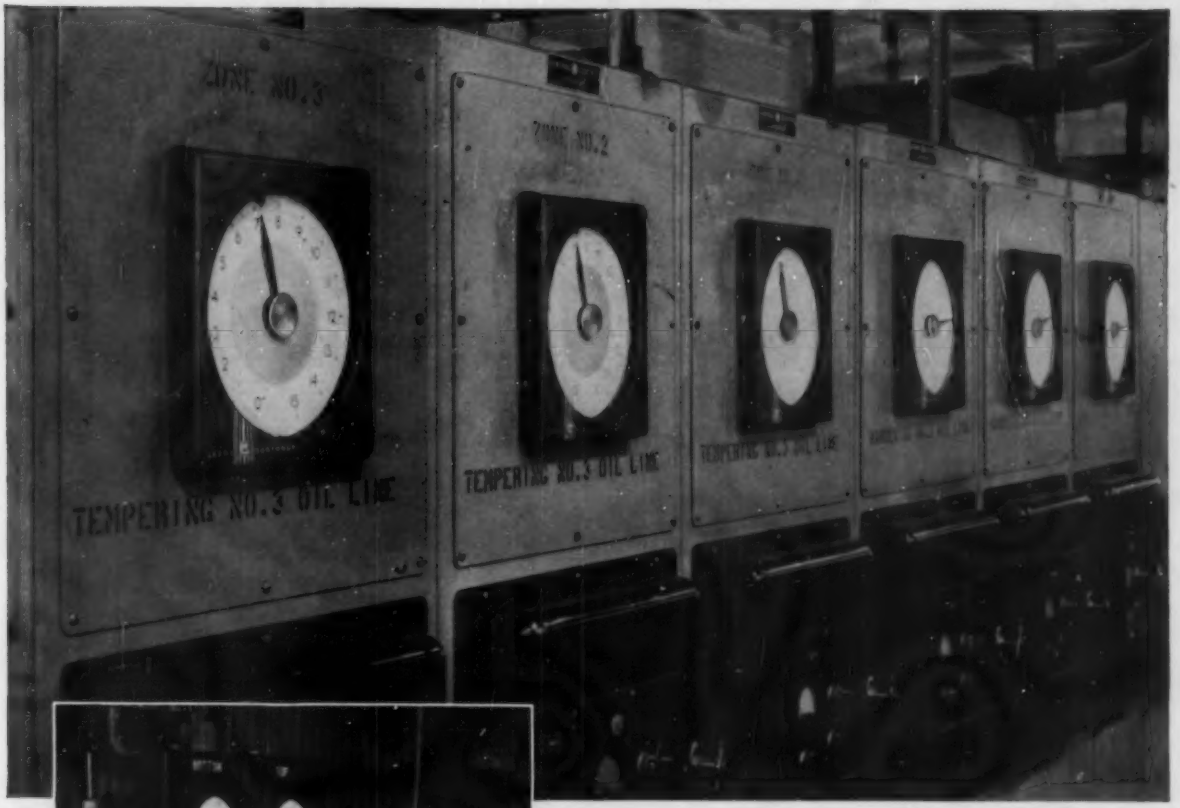
The aging process was also accelerated by tensile-compressive straining at 0.05 and 0.10%. The greater effect occurred at the strain of 0.10%.

Ultrasonic vibration produced no acceleration in the rate of aging.

Prior deformation has been shown to affect the aging process in plain carbon steel. The authors, therefore, investigated the degree of aging, as measured by the impact test, produced by cyclic stressing after prior deformation. Square-section specimens were used for the cyclic stressing and then were prepared for notch toughness testing.

Prior reductions of 0.2 to 10% with aging at room temperature caused only a slight decrease in toughness due to cyclic stressing. The effect of cyclic stressing, however, is considerable at higher temperatures; for example, a cyclic strain of 0.1% after a prior reduction of 5% produced a sharp decrease in notch toughness at 212° F. which was comparable to the decrease in the control specimens at 300° F.

W. A. MORGAN



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# Some Notes About Authors

### Pierre Coheur

Pierre Coheur, the senior author of the leading article in this 1957 review of international progress in metallurgy, was primarily concerned with physical metallurgy until 1947 when he began to study the problems related to steelmaking. To gain more knowledge of this field, he spent two years in a Liège, Belgium steelworks, and then visited many steelworks and educational and research centers in Europe, North and South America and India. Professor Coheur is a professor at the University of Liège, where he received his own metallurgical education, and is also director of the Liège Section of the Centre National de Recherches Métallurgiques.

### Eduard Nachtigall

Eduard Nachtigall, author of the article on "Development of the Aluminum Industry in Austria," has been director of research of the laboratories of Vereinigte Aluminium-Werke A. G. and the Oesterreichische Metallwerke A. G. in Ranshofen, Austria, for the past six years. A native of Vienna, he was educated at the Institute of Technology and University there, and from 1931 to 1937 served as research assistant and taught in the department of metallurgy at the institute, while working on a research grant from Dynamit Nobel A. G. As director of the metallurgical department of the material testing branch of I. G. Farbenindustrie A. G., Bitterfeld, Germany, from 1938 to 1947, Dr. Nachtigall developed chemical and electrolytic protective coatings for aluminum and magnesium. Returning to Austria, he was head of the research laboratories at the Metallwerke Plansee in Reutte, Austria until 1951.

### Hans Kosmider

Hans Kosmider, Professor Coheur's co-author, is chief metallurgist and director of research of Kloechner steelworks in Duisberg, Germany. He has done research on the application of oxygen in openhearth furnaces and converters, and with his co-workers developed special blowing processes for the converter steel method using enriched air and a mixture of oxygen and steam.

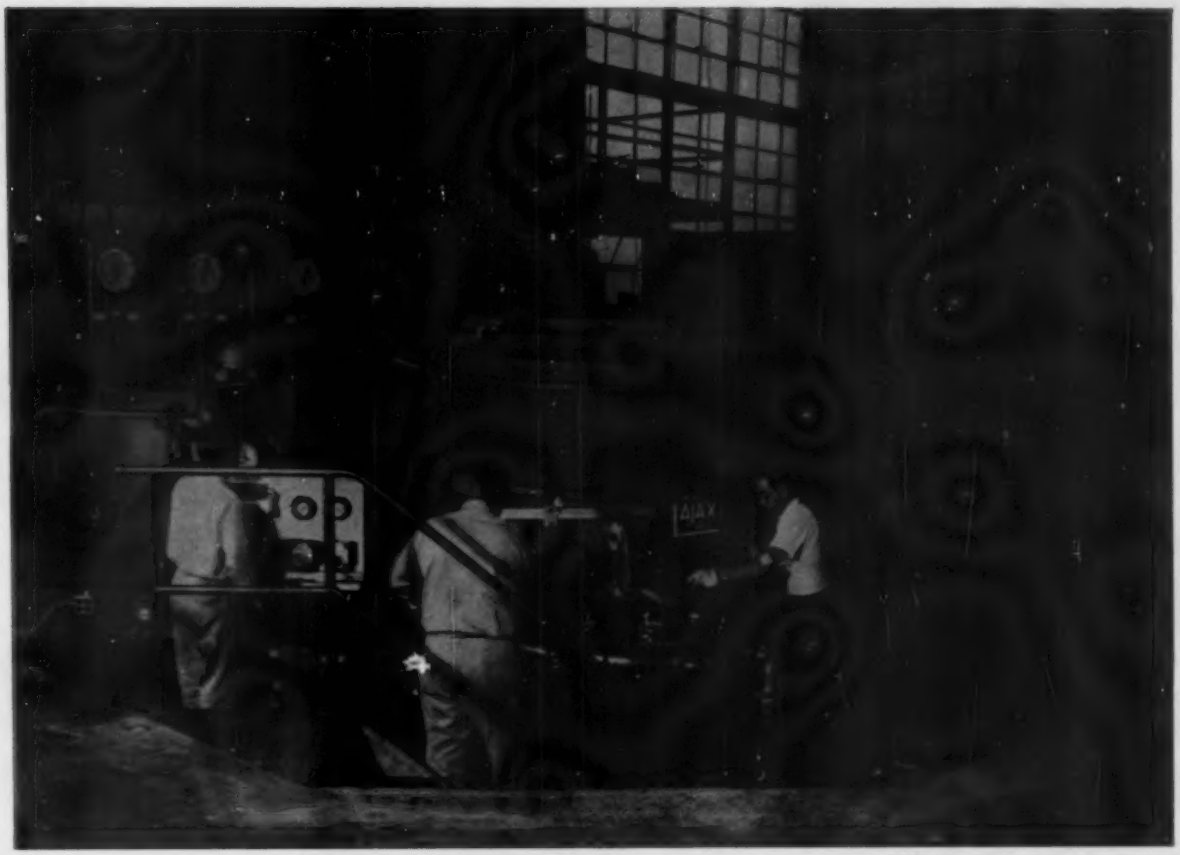
### G. W. Seulen

As managing director of AEG-Elotherm, one of the leading firms in Germany concerned with induction heating and melting, G. W. Seulen is well qualified to write about induction heating. A native of Braunschweig, Germany, he studied at the university there, receiving his bachelor's and doctorate degrees. After his graduation he joined the Allgemeine Elektricitäts-Gesellschaft, and in 1939 began working in the induction heating field.

### Paul Blain

Paul Blain graduated as an engineer from the Ecoles Nationales d'Arts et Métiers and from the Ecole Supérieure d'Electricité in Paris. He has served successively as head of the rolling mill department, chief engineer and technical di-

(*Continued on p. 222*)



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## Authors . . .

rector of the Firminy works of the Société des Aciéries et Forges de Firminy, where he studied and developed new types of rolling mills. At present Mr. Blain is consulting engineer for the Compagnie des Ateliers et Forges de la Loire and for the Institute de Recherches de la Sidérurgie.

### Adalbert Wittmoser

A native of Latvia, Adalbert Wittmoser managed his family business Eisengiesserei und Maschinenfabrik K. Vitmozeris in Mariampole, Latvia, until 1942 when he began his graduate studies at the Technische Hochschule, Aachen, Germany. He received his master's and doctor's degrees there while working as an assistant at the school's Institute of Foundry Technology. After several years as director of the research laboratory of Eisenwerken Gelsenkirchen A. G., Dr. Wittmoser returned to Technische Hochschule, Aachen, in 1953 as professor of foundry technology.

### Georges Stempfel

Soon after receiving his doctorate from the University of Strasbourg, Georges Stempfel joined the Société d'Electro-Chimie, d'Electro-Métallurgie et des Aciéries Electriques d'Ugine as an engineer concerned with cyanide salts for heat treatment and surface treatment. He became director of the testing department for cementation and applications of cyanides of the Société d'Electro-Chimie in 1934, and held this position until 1943 when a subsidiary of the company was formed, the Société Anonyme pour l'Application des Produits Spéciaux Durferrit-Sofumi. He was named director of the heat treating department of this subsidiary and subsequently technical director of the company. In addition, Mr. Stempfel is a professor at the Ecole Nationale de Radiotechnique et d'Electricité Appliquée in Paris.

### G. T. Harris

G. T. Harris has been with the research department of William Jessop & Sons, Ltd., Sheffield, England, since 1938. In addition to organizing a creep testing laboratory (which has grown from two creep units in 1938 to 200 in 1956) and conducting research on the mechanical properties of steels, Mr. Harris has been particularly interested in the development of heat resistant steels for jet engines. Jessop has been associated with jet engines since their early development and now makes a major part of the turbine disks for British jets. The company's activities have recently been extended to titanium, and after three years research a production plant is now in operation. Mr. Harris was appointed research director for William Jessop and Son in 1951, having served as research manager since 1947.

Three traveling American metallurgists help round out our international issue by presenting some astute observations concerning their particular specialties in other parts of the world. Francis C. Frary, who attended the Third International Light Metal Congress reported on p. 81, retired as director of research for Aluminum Co. of America in 1952. He continues to serve as a technical advisor for the company. Lee Wilson, chairman of the Lee Wilson Engineering Co., visited Russia last summer, with the primary purpose of selling some of the steel plant furnaces his company specializes in. During his stay he kept an extensive diary from which his impressions of Russian steel mill practice are culled. Finally, in a letter in the correspondence department, Harry B. Obsorn, Jr., technical director, Tocco Div., Ohio Crankshaft Co., tells about heat treating in Mexico. His report also is based on a business trip.

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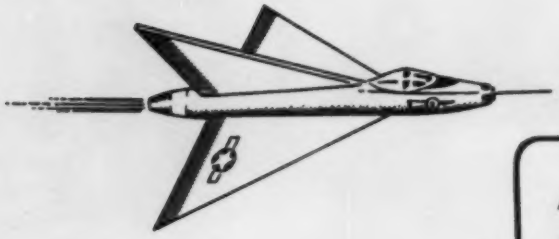

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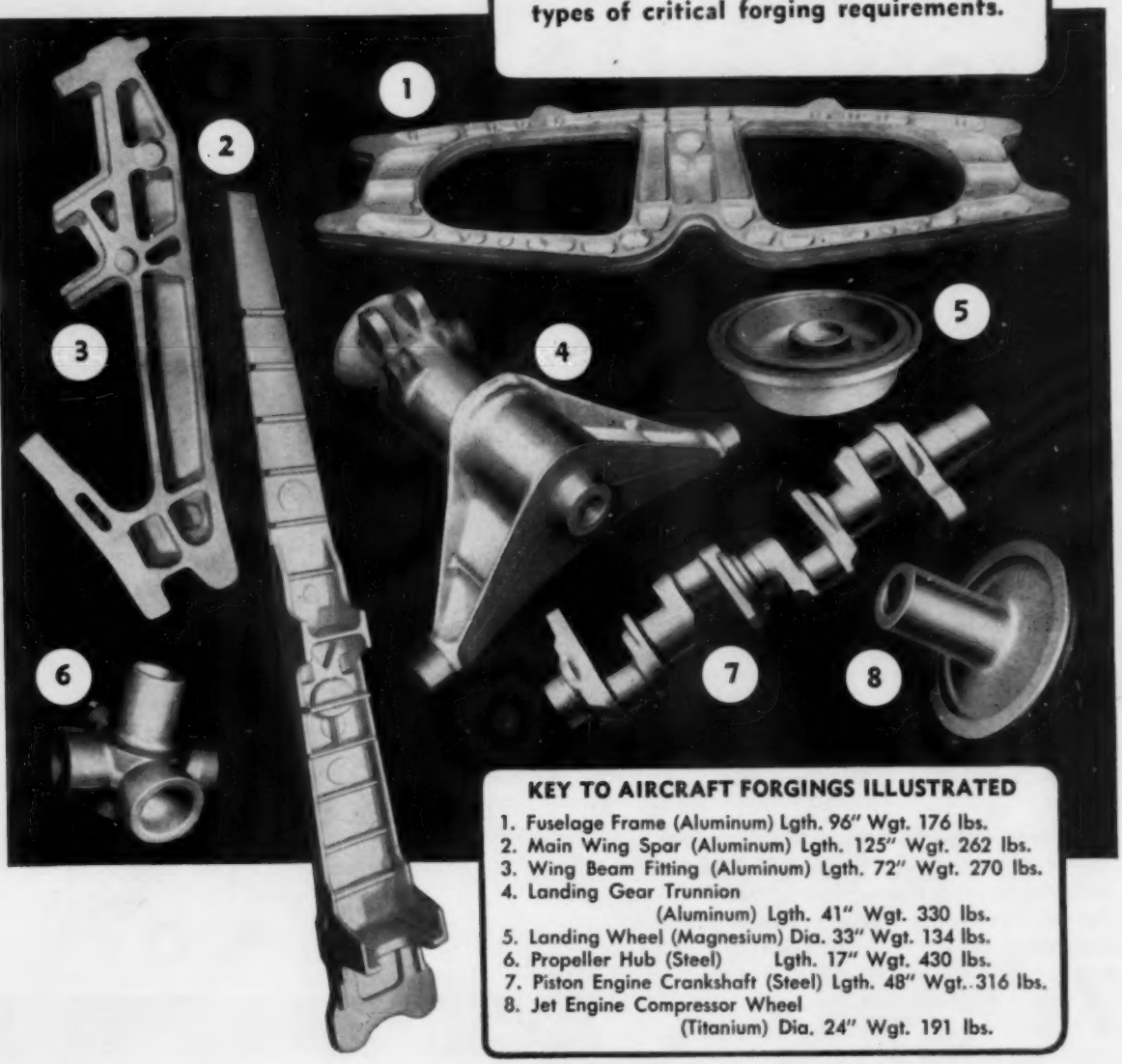


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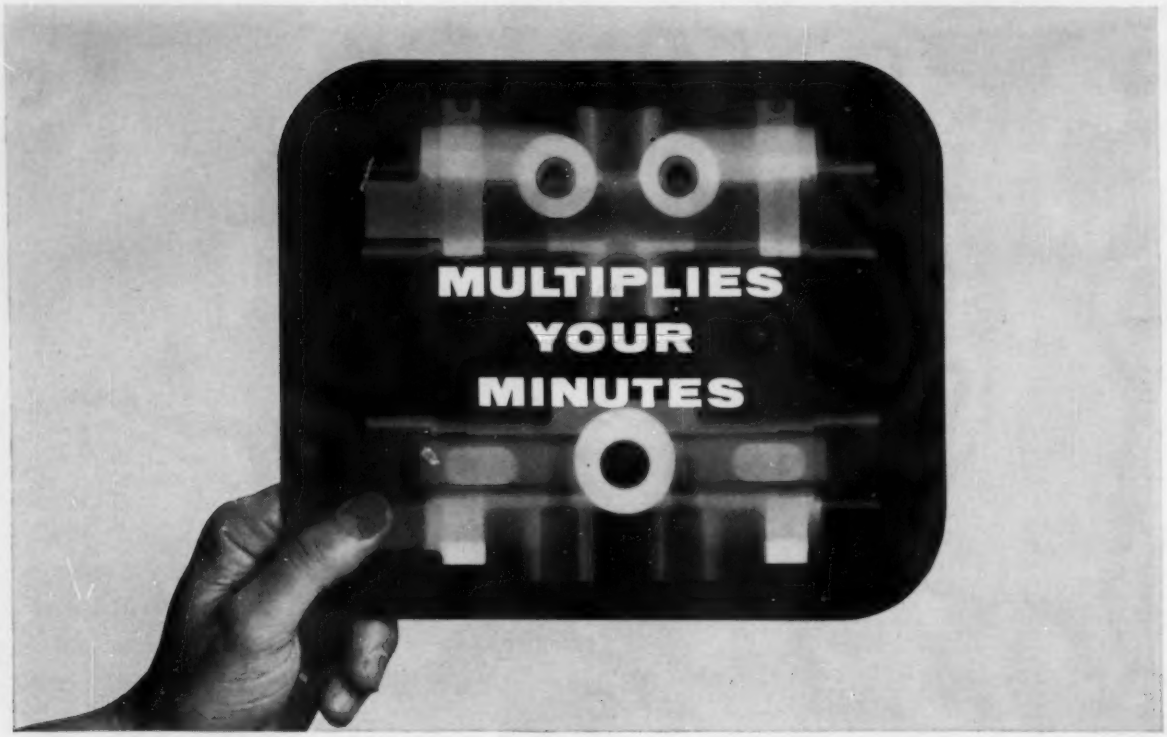


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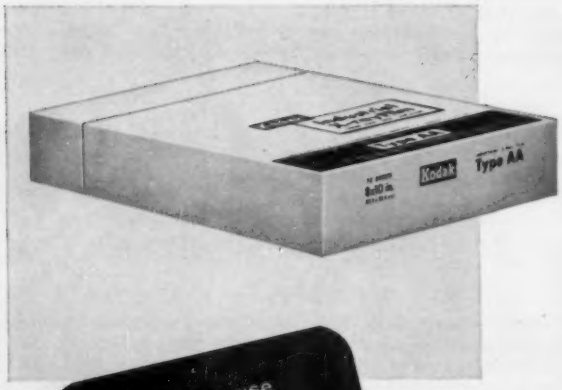


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Business is good today—but—the concern for tomorrow and its profit is of vital importance to all in industry. Fortunate indeed, are those companies who use ACCOLOY Heat and Corrosion-Resistant Castings. These manufacturers know that ACCOLOY castings with their reputation for long service life, give assurance of continuous profit in tomorrow's production lines.

Produced under rigid quality control by skilled workmen, ACCOLOY castings are designed to meet your specific needs. In maintaining their leadership in quality castings, Alloy Engineering & Casting Co. has engineers and offices located across the nation who are most willing to help you with your casting problems. Ask for their help without obligation.

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You and the management, engineering, production and purchasing men you work with will earn and learn much more than the cost of your visit to this great Metal Show. It will be just like touring 500 plants in the metal industry, which would otherwise take months of your time.

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BEST WISHES FOR
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P&H Welding Positioners give you

# GREATER CAPACITY and GREATER VALUE for every dollar you invest

**3000-LB. MODELS/LOAD-CAPACITY COMPARISON CHART**

Capacity Shown Below at 12" off center of Rotation and Distances of Center of Gravity of Load from Table.

| Distance Positioner | 12" | 18" | 24" | 30" | 36" | 42" | 48" | 54" | 60" |
|---|---|---|---|---|---|---|---|---|---|
| **P&H** | **3000** | **2510** | **2160** | **1900** | **1690** | **1520** | **1390** | **1270** | **1180** |
| A | 3000 | 2000 | 1500 | 1200 | 1000 | – | – | – | – |
| B | 3000 | 2250 | 1800 | 1500 | – | – | – | – | – |
| C | 2987 | 2187 | 1725 | 1424 | 1212 | 1056 | 935 | 839 | 760 |

This chart shows how a typical 3000 lb. P&H welding positioner handles loads far beyond the positions where competitive makes quit! P&H positioners handle big, bulky or odd-shaped weldments with ease because of these three features:

**More table tilt — 135 degrees**

**More clearance for rotation — no legs or posts interfere**

**Higher table elevation — even under capacity loads**

Capacities range from 500 to 100,000 lbs. Send for "Load Capacity Data Sheet No. 2" to help you select the positioner best suited to your needs. Write Bill Stephens, Sales Manager, Welding Division, Harnischfeger Corp., Milwaukee 46, Wis.

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# AUTOMATIC HEAT TREATING

## *with* Magnethermic Induction Heaters

## KEEPS PRODUCTION MOVING

Here is another example of automatic heat treating with Magnethermic Induction Heaters and automatic feeding. This Magnethermic installation keeps parts moving at a steady rate to subsequent operations. Loading is necessary only once per shift.

You know the advantages of **automatic heat treating** as an integral part of a production or machining line . . . saves handling, controls quality, eliminates extra equipment and, most important, keeps parts moving continuously.

**A Magnethermic** application engineer will be glad to show you how automatic heat treating can help reduce manufacturing costs and provide controlled product quality.

**An inquiry to Magnethermic** for automatic heat treating or any other induction heating application will receive prompt, intelligent attention. Magnethermic makes a complete line of high and low frequency induction heating equipment.

**see MAGNETHERMIC for Induction Heating**

INDUCTION HEATING EQUIPMENT

MAGNETHERMIC corporation

3990 SIMON R[illegible] YOUNGSTOWN 7, OHIO

**Does your sketch suggest a copper-base alloy?...**

*You name it...*

**Ampco can supply it, in the form that's best**

You enjoy design flexibility, with versatile Ampco alloys

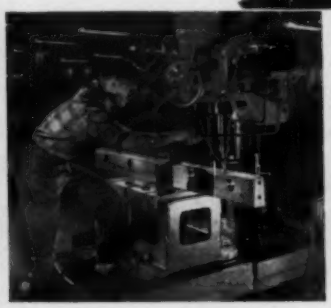
Among more than 100 Ampco copper-base alloys is the one you need for

- — resistance to wear, impact, fatigue, corrosion
- — excellent bearing qualities
- — retention of physical characteristics at temperatures from 600°F down to –400°F.

And equally important, you can select the best, most economical form of production — sand casting, centrifugal casting, shell mold, precision casting, forging, fabrication, extrusion, sheet, plate.

Call in your Ampco field engineer.
Write for Bulletin 33.

**Sand castings** in any size up to 14,000 pounds — and *centrifugal castings* up to five tons—are produced in Ampco foundries.



**Ampco's one-source service** includes production-run machining of copper-base alloys to quality standards of the aircraft industry.



**2,275-ton hydraulic** press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

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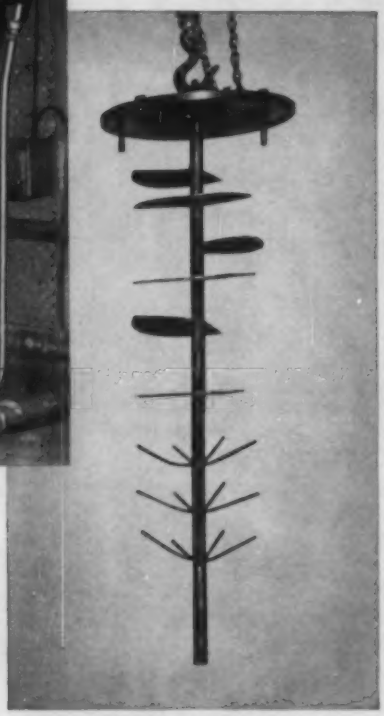
**Performance is top-notch** in Pacific's new vacuum furnace. Inconel alloy retort withstands severe heat-treating conditions, aids operation. Installation shown is at Western Gear Corp., Los Angeles.



**Inconel work holding fixture** and heat deflecting baffle is lowered into the Inconel retort from above. Inconel alloy lends itself well to the intricate forming and welding called for in making both this fixture and the retort itself.

# Inconel retorts help industry explore high vacuums for production heat-treating

What's the best way to prevent brittleness in surface hardening of titanium? Is it practical to finish high alloy parts to tolerance and *then* stress relieve them?

Several concerns are looking into such questions . . . using vacuums up to 0.1 microns.

At Western Gear Corporation the work is done in an interesting new Pacific Scientific Company furnace equipped with an Inconel nickel-chromium alloy retort. The furnace is controlled by instruments and sized for production-run batches. It can be loaded without disturbing vacuum and service connections and back flushed with any desired atmosphere.

### Inconel alloy aids operation

Pacific's use of Inconel nickel-chromium alloy aids operation of the furnace in several ways.

First, with wrought Inconel alloy, the retort withstands the severe operating conditions imposed by production research. Long-continued high vacuums at heat don't harm it. Neither do thermal shocks from rapid cooling. Nor corrosive atmospheres.

Second, Inconel simplifies the furnace construction. And its good "hot" strength helps in practical design. What's more, no special work handling fixtures or costly seal constructions are needed. That's because the low coefficient of expansion of Inconel permits retort and furnace to be designed as a single unit.

Third, Inconel can be readily welded to give a strong vacuum-tight joint that stays gas-tight.

### More information available

For details concerning this furnace, contact Pacific Scientific Company, Los Angeles, California. For information on the use of Inconel alloy in heat-treating equipment, write Inco for "Keep Operating Cost Down When Temperatures Go Up . . .", a picture-packed Inco booklet. *Registered trademark

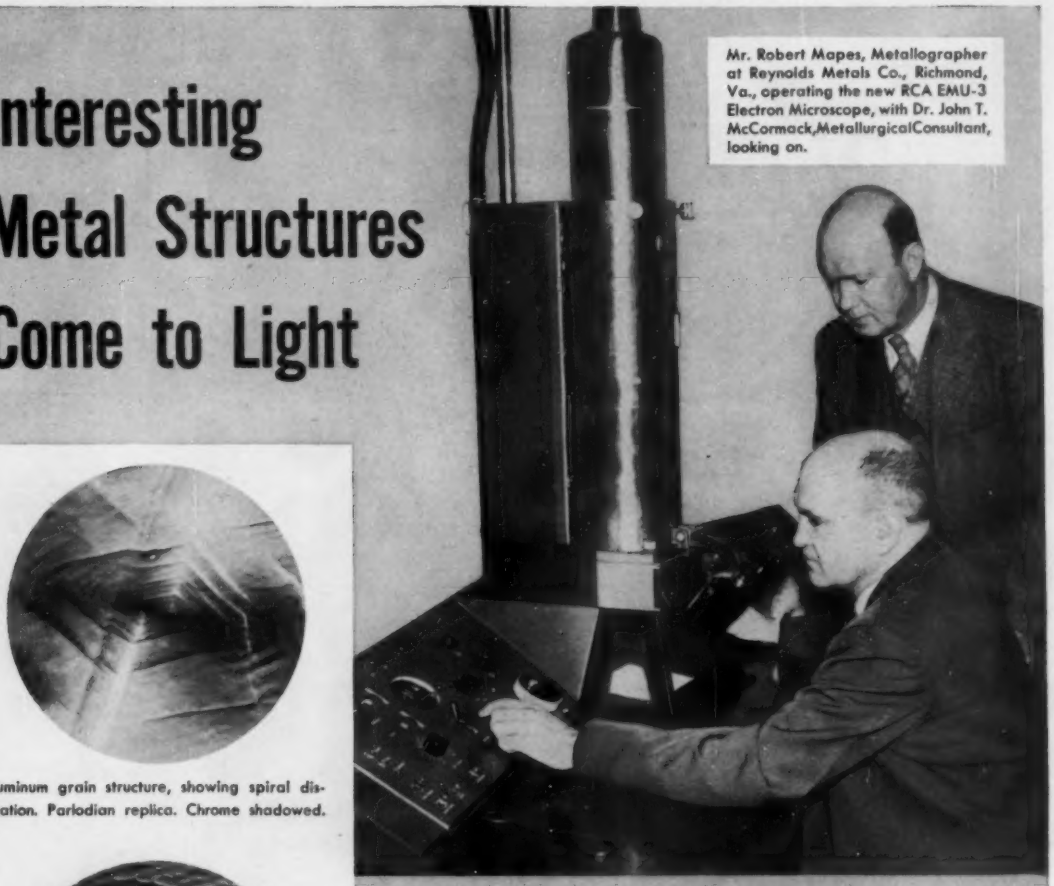
**The International Nickel Company, Inc.**
67 Wall Street New York 5, N. Y.

**Inconel**

INCO TRADE MARK **Nickel Alloys**

*. . . for long life at high temperatures*

# Interesting Metal Structures Come to Light



Mr. Robert Mapes, Metallographer at Reynolds Metals Co., Richmond, Va., operating the new RCA EMU-3 Electron Microscope, with Dr. John T. McCormack, Metallurgical Consultant, looking on.



Aluminum grain structure, showing spiral dislocation. Parlodian replica. Chrome shadowed.

Aluminum grain showing sub-grain structure. Parlodian replica. Chrome shadowed.

## . . . with the RCA Electron Microscope

In fundamental research with the electron microscope, Reynolds Metals Company examines metal structures by surface replica techniques and contrasts enhanced by "shadowing" with a thin film of chromium. Structures too small to be seen with the light microscope are clarified and features revealed by electron micrographs. Such studies are leading to improved performance and fabrication characteristics in the metals.

The electron microscope also is used on ferrous metals for quantitative measurement of grain size, undissolved carbides, retained austenite and other secondary phases.

Ideal for basic research and development work, the latest EMU-3 and EML-1 Electron Microscopes provide magnification and resolution higher than ever before possible and include many advanced engineering features. We invite you to find out more about this revolutionary new RCA equipment as a solution to your research problems. Installation supervision is supplied and contract service by the RCA Service Company is available if desired.

**For further information write to Dept. N-72, Building 15-1, Radio Corporation of America, Camden, N.J. In Canada: RCA VICTOR Company Ltd., Montreal**

RCA

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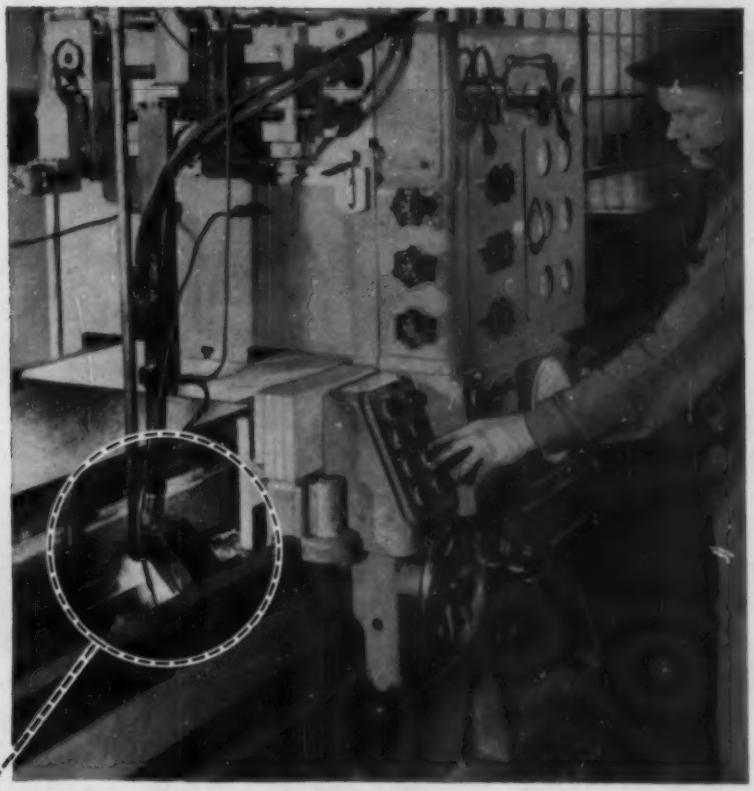
# HIGH SPEED FLAME-HARDENING



*Cross-section view shows uniform depth of hardened surface.*

## SPECIAL MACHINE UPS LIFE OF GRAPHITIC STEEL PARTS

LINDE engineers have assisted Cincinnati Steel Treating Company in developing a flame hardening machine which increases service life of 16 ft. long, graphitic carbon steel lathe ways . . . Development of this automatic, high speed machine is another example of how LINDE Service Engineers are helping LINDE's customers up production speed and unit quality through co-operative research engineering.

With this new machine, a lathe way to be treated is placed on a magnetic chuck in a water filled channel. Flame-hardening heads and control mechanism move at predetermined speeds along the part. After it cools, the lathe way is placed in a refrigerator for 24 hours which stabilizes the steel, and brings its case hardness to a minimum of 60 Rockwell "C" scale.

The benefits of LINDE's research, engineering, and over 40 years of accumulated know-how stand behind each of its customers to help them solve production problems. Get these "plus-values" which LINDE offers—it pays you to do business with LINDE.

**Linde Air Products Company**
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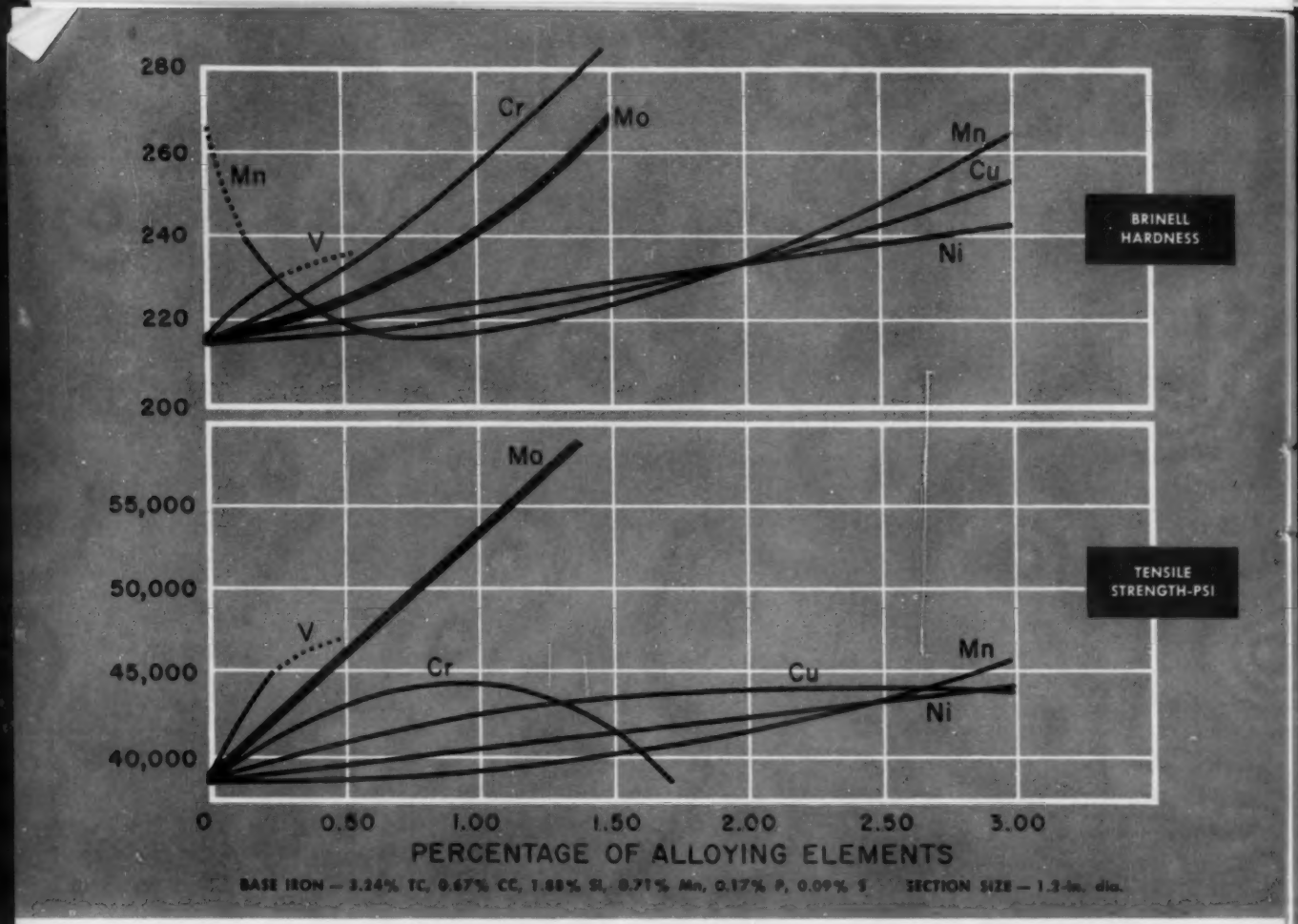


Note how additions of moly, up to 1.5%, produce proportional improvements in strength. And, with moly, hardness increases much more slowly. It means higher strengths can be used with less danger of impaired machinability.

# each ½% Moly adds 7000 psi to strength of cast iron...

A little moly adds a lot of strength – for molybdenum increases strength more than any other common alloying element, with the exception of small vanadium additions. A rule of thumb is that fifty points of moly raise tensile strength 7000 psi. And without sacrificing toughness. Actually, moly improves toughness at least as much as strength.

What's more, versatile moly aids in obtaining uniform response to heat treatment . . . and in producing machinable, growth-resistant castings. Moly is easy to use, too.

With most grades of cast iron, moly requires no change in the character of the charge, normal melting practice, or the base metal. And foundrymen like the fact that the small additions necessary may be made at the spout or in the ladle.

Write now for "Why Moly Iron". It's the full story of how and why moly adds strength faster than hardness, how it increases fatigue and torsional strength—in short why moly makes better cast iron. Climax Molybdenum Co., Dept. 5, 500 Fifth Avenue, New York 36, N. Y.

**CLIMAX MOLYBDENUM**

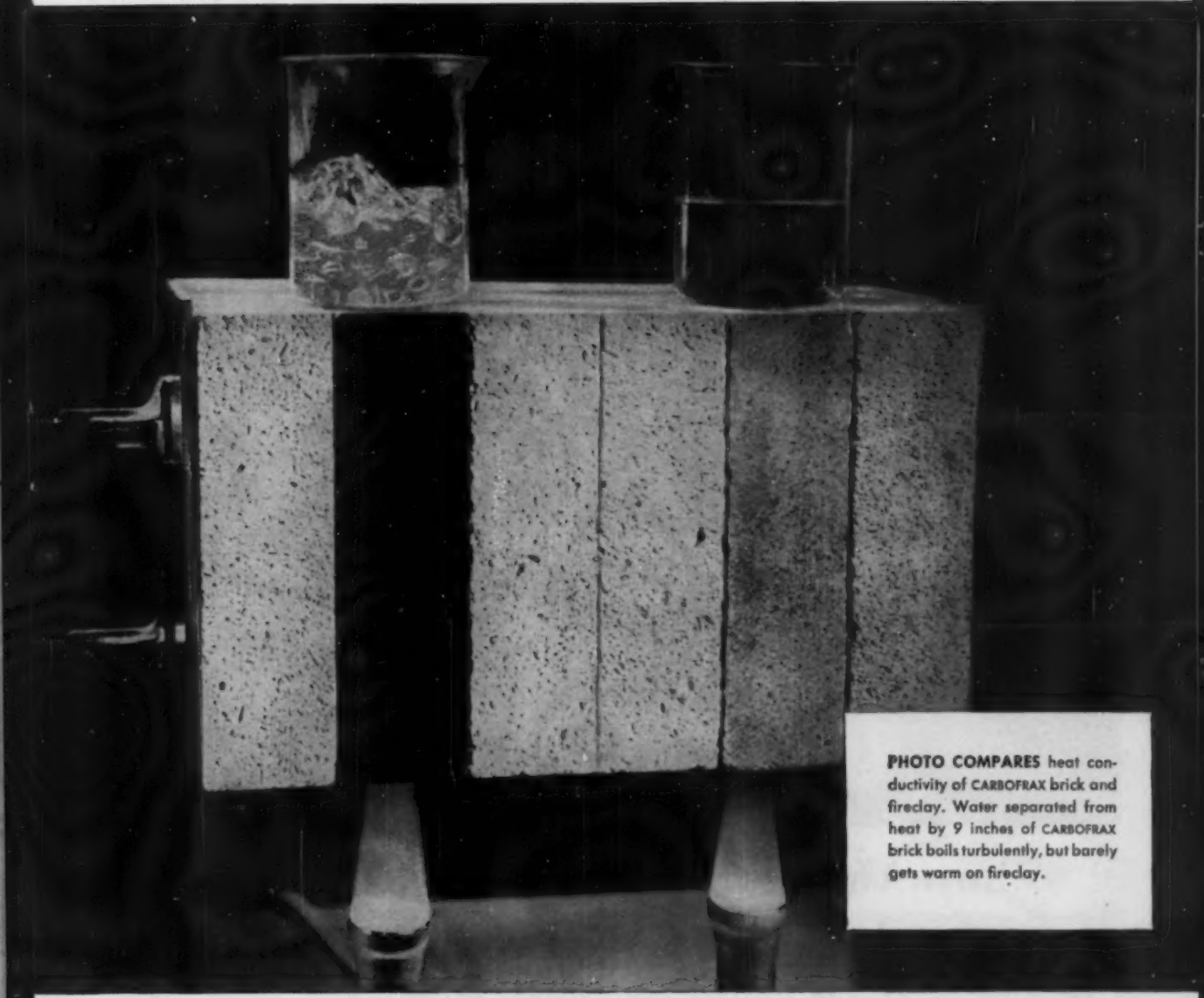

**PHOTO COMPARES** heat conductivity of CARBOFRAX brick and fireclay. Water separated from heat by 9 inches of CARBOFRAX brick boils turbulently, but barely gets warm on fireclay.

# Refractories–for high heat conductivity

High heat conductivity—roughly 11 times that of fireclay and about 70% that of chrome-nickel steels—is one of the properties of CARBOFRAX® silicon carbide refractories. It is an ideal material for muffles, radiant tubes, retorts and similar structures where you need exceptional resistance to direct flame plus the ability to conduct heat efficiently. At 2200°F, thermal conductivity of CARBOFRAX brick is 109BTU/hr., sq. ft. and °F/in. of thickness.

CARBOFRAX refractories typify the many super refractories pioneered by Carborundum. Each has a wide range of properties. One, for example, is formed into precision parts that look like cast iron yet resist over 3000°F. Another, a new ceramic fiber, filters and insulates at temperatures no existing mineral or glass fiber can take.

**CARBORUNDUM**
Registered Trade Mark

For valuable information about high temperature problems—and other pertinent information about refractories—or for help on your own particular problem—fill in and mail this coupon today:

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# how Vacuum Metals FERROVAC solved critical surface problem for Bausch & Lomb . . .

The jewelers' rolls Bausch & Lomb use to roll gold-alloy wire for eyeglass frames must be *mirror-smooth*. Rolls of conventional air-melted alloys just didn't work out economically. A normal amount of nonmetallic inclusions in the metal meant they had to be ground and reground, polished and repolished, before the surface was satisfactory. And even then, many rolls had to be scrapped when finishing uncovered inclusion pits.

The solution to this problem proved to be Vacuum Metals FERROVAC® Airdi 150. A better finish was obtained without any regrinding—and the number of scrapped rolls fell to zero. Here's why: Vacuum-melting removes the gases which create nonmetallic inclusions in the molten metal before they get into the product. This means cleaner metal, smoother surfaces. What's more, vacuum-melting improves fatigue, creep and impact strengths . . . reduces brittleness.

Vacuum-melted metals are the answer to jobs where surface is critical—like gauge blocks, plug and ring gauges, rolls for aluminum foil—as well as many other specially demanding applications. They're available in most grades and sizes, including special ferrous and non-ferrous alloys. Write now for a free analysis sheet on which to describe your application. It will help us both decide how vacuum-melted metals can serve you best. *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, New York.*

VMC®

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**Division of Crucible Steel Company of America**

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Nuclear power offers tremendous advantage for naval vessels. From the fuel standpoint, cruising ranges are virtually unlimited—even at new high speeds. No refueling facilities will be required to replenish nuclear propulsion fuel. Therefore, the physical design of the fleet can be streamlined for greater efficiency and safety.

At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: the development of fuel alloys; the development of clad alloys; fuel element development; and technical control of fuel elements and fuel and clad alloys. At Bettis you will have a choice of working in either Basic or Applied Metallurgy. You may prefer to conduct basic research in areas like these: 1) Solid phase transformation, 2) Corrosion kinetics and mechanisms, 3) Effect of irradiation on metals, 4) Internal friction studies, 5) Study of equilibrium diagrams.

To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

**Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A71, P.O. Box 1468, Pittsburgh 30 Pa.**

## BETTIS PLANT
## Westinghouse

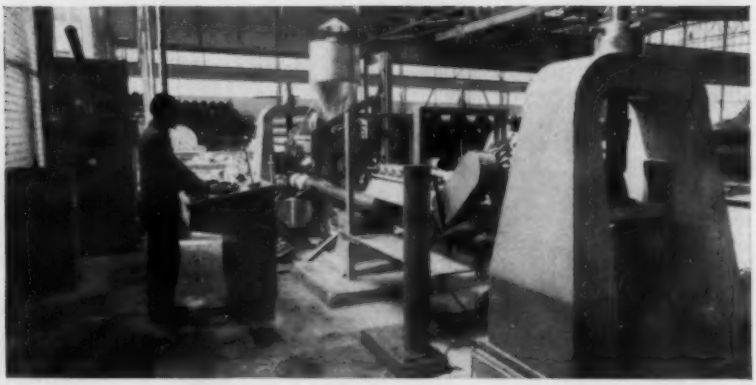
# Case Studies:
## NONDESTRUCTIVE TESTING SYSTEMS

**The MAGNATEST FW-400 Series** is electronic, eddy current equipment for nondestructive testing of non-magnetic rod, wire, or tube from 1/64" to 3" diameter. The test is fully automatic and can run at high mill rates (up to 400 and 500 f.p.m.). With the FW-400 such problems as seams, cracks, concentrated porosity, inclusions, stringers, laps, and splits may be detected at the level required. Diameter variation, embrittled areas, and scale are other conditions found with the unit.

**SEMI-AUTOMATIC MAQ 1694 MAGNAFLUX.** Unit speeds end inspection for rod mills. A special conveyor extension carries short coil-end samples through a Magnaglo bath. They are then magnatized automatically and pass on to the curtained "black light" booth where defects, if any, show up as glowing indications on the rod ends. The Rate: 15 per minute. This system has cut inspection time in half and has eliminated the need for most acid etching equipment at several mills.

HALLMARK OF QUALITY IN NONDESTRUCTIVE TEST SYSTEMS

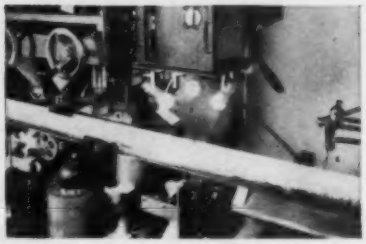
**Write for complete details concerning any of the above case studies or other tests in mills. Also, ask for our new booklet on "Lower Manufacturing Costs."**



This picture shows the first new fully automatic Magnaflux PYQ equipment used in a steel mill on pipe weld testing. The man operates the mill itself, the Magnaflux unit uses photoelectric inspection.

# New Methods Developed for Mill Tonnage Testing

Nondestructive testing has grown from a "sometimes" thing to a full time production tool in many mill operations. New techniques and methods have been developed for every type inspection. Whether the mill produces rods, tubes, rounds, squares, bars or billets, M offers semi or fully automatic inspection systems for practically every need. For instance, the type of defect most commonly found in resistance welded steel line pipe is longitudinal cracks in the weld. As shown in the illustrations above and at the right, such cracks can now be detected automatically right after welding. The crack is spray-marked on the pipe. This is done at production line speeds and without operator optical fatigue factors.



This unit tests pipe welds at rates over 100 ft. per minute. Magnaflux indications of defects are formed at location #4 in photo above. The new SN-100 Series photoelectric scanner automatically "sees" these defects at #5 area. This actuates #6 spring, wherever crack is present — to mark defect with paint.

**MAGNAGLO INSPECTION VARIES TO FIND *ONLY* WHAT YOU WANT TO SEE!**

After you decide what constitutes your own serious flaw, Magnaglo can help you achieve consistent quality in production. The magnetizing current and Magnaglo application can be varied and controlled to produce exactly the degree of sensitivity required for your quality standards. The photos above show the same billet inspected under varying techniques and amperages, to suit different billet conditioning needs.

Note: variance of intensity of the Magnaglo indications. You can show or not show any depth seam you require, for each job you run.

Zyglo can be similarly employed on nonmagnetic billets, to increase yield and lower conditioning costs.

Take Your Inspection Problems to the House of Answers . . .

**MAGNAFLUX CORPORATION**

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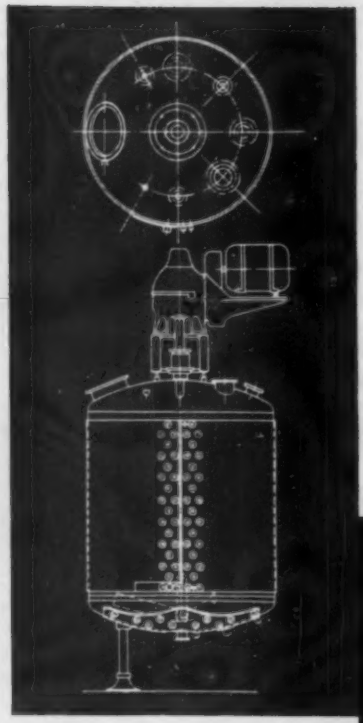
# can you afford not to use TITANIUM?



By themselves, catalog prices of raw materials can be misleading. For it's the final cost—in terms of service life—that really determines what you pay for equipment.

The following table, based on cost analysis by the Pfaudler Company, indicates their estimate of comparative costs of producing the reactor unit shown at the left, using titanium, and two other well-known, corrosion-resistant metals.

| | REM-CRU A-55 TITANIUM | METAL A | METAL B |
|---|---|---|---|
| Cost per lb. | $14.60 | $0.8025 | $2.62 |
| But titanium's light-weight means less is needed . . . | | | |
| Material Required | 250 lbs. | 785 lbs. | 675 lbs. |
| So the comparative cost factor is reduced . . . | | | |
| Material Costs | $3650.00 | $630.00 | $1768.00 |
| Fabrication takes the lions' share, so . . . | | | |
| Cost of Finished Reactor | $12,150.00 | $2391.00 | $4670.00 |
| And in corrosive chlorides, hot acids, and many other environments, laboratory and service data show . . . | | | |
| Service Life | 5 years | 6 months | 1 year |
| **NOW . . . COST Per Service Year** | **$2430.00** | **$4782.00** | **$4670.00** |

Reactor unit of REM-CRU titanium built by the Pfaudler Co., Rochester, N. Y. and Elyria, Ohio a skilled fabricator of titanium and other corrosion-resisting materials.

Don't be fooled by raw material costs alone—*it's the cost per service year that really counts.* Then, too, down-time losses while equipment is being replaced can quickly mount up. Another plus for longer-lasting titanium. Why not let a REM-CRU engineer help you make the best, most profitable use of titanium?

**REM-CRU TITANIUM**

***To keep abreast of the latest developments on this vital metal, write to Dept. MP-1 for the Rem-Cru Review—a free periodical presenting the latest technical data on titanium alloys.***

**REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA**

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Since 1930, ENTHONE Incorporated has developed and brought to the metal finishing market many specialty products and processes. Often these products have provided the answers to finishing problems previously unsolved. ENTHONE ENSTRIPS, for example, are patented products for the selective dissolving of one metal plated on another without attacking the base metal.

**ENSTRIP A**—U.S. Patent No. 2,649,361—was the first product ever offered for dissolving nickel plate without attack on the steel basis metal.

**ENSTRIP 165-S**—U.S. Patent No. 2,698,781—was the first product ever offered for dissolving nickel from copper base alloys without attack on the basis metal. And there are many other selective strippers in the ENSTRIPS group to meet all requirements.

If you have a metal finishing problem, ask ENTHONE *first!* Write now for the folder "They are HERE . . ." describing **20** ENTHONE answers to difficult finishing problems.

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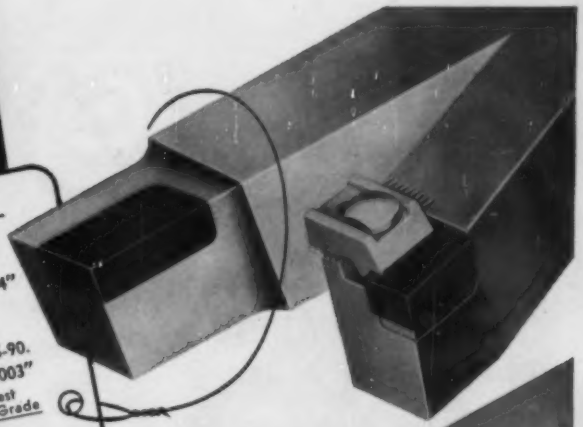
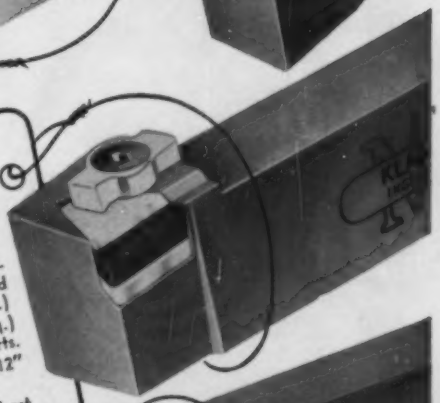


**COSTS ONLY $1.65** Leading appliance manufacturer gets superior results with Talide standard brazed-type tool.

Machine..... Gisholt Turret Lathe.
Part..... Stud for automatic washing machine 3/4" dia. x 4" long, 1045 Steel, Rockwell 28 "C".
Operation..... Complete finishing including threading of end.
Tool..... Standard Talide tool AL-10-5/8" sq. x 4", Grade S-90.
Speed (S.F.M.)....400 Feed....005" Depth of Cut....003"

| | Talide Grade S-90 | Next Best Premium Grade |
|---|---|---|
| Average No. of pcs. per grind ..... | 600 | 475 |
| Average No. of regrinds per tool ..... | 16 | 14 |



**90 DAYS OF GRUELING TESTS** at eastern aircraft engine plant rates Talide Grade S-92 "Best by Test."

Here is one typical result:
Machine..... 36" Bullard Multimatic
Material..... AMS-5613 Stainless Steel
Operation..... Facing, turning and boring 21" O.D. x 2.5" thick casting to size. (Heavy scale, bead weld, and out of round surfaces presented adverse machining conditions.)
Tools..... TN-163P3 (1/2" I.C.) and SN-243P3 (3/4" sq.) Talide "Throw-away" triangular and square inserts.
Speed (S.F.M.)..... 375 to 1100 Feed..... .006" to .012"
Depth of Cut....060 to .500
Result..... 27-34 Pc. average compared to 7-12 for next best premium grade—plus tool breakage cut 75%.

**BEST CUTTING METAL FOR MACHINING CRANKSHAFTS**

A large midwest automotive plant recently conducted an extensive test to determine the best cutting metal for machining crankshafts—the results proved TALIDE "BEST BY TEST!"

Machine..... Fay Automatic Lathe Feed..... .006"
Speed..... 800 R.P.M. Depth of Cut..... .035"
Cutting Tool..... Style TB-12123 Triangular Insert

| Material | Talide Grade S-90 | 2nd Best Carbide | 3rd Best Carbide |
|---|---|---|---|
| 1141 Steel | 175 pcs. | 120 pcs. | 97 pcs. |
| 4140 Steel | 128 pcs. | 70 pcs. | 65 pcs. |
| Armor Steel | 83 pcs. | 65 pcs. | 65 pcs. |

**CONSTANT RESEARCH PAYS OFF!**

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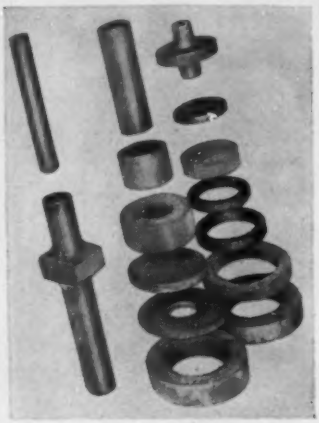

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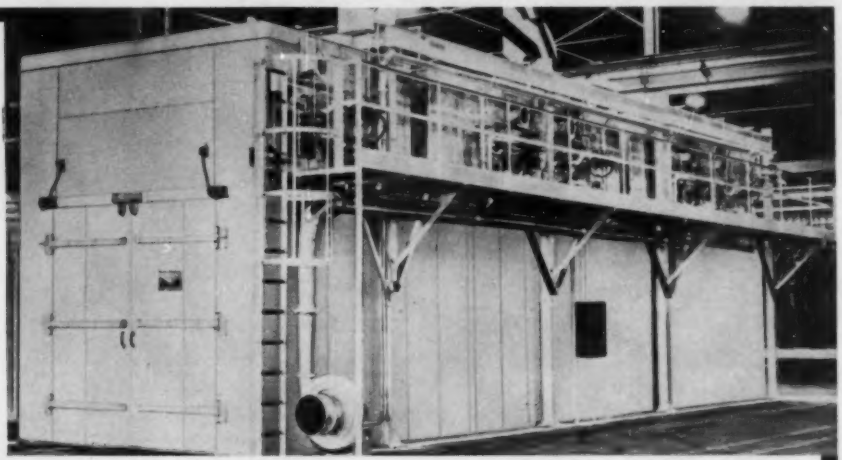
You can't afford inefficient light metal processing



Manufacturers, nation-wide, are searching for ways to cut production costs. Many have found an answer—increase the efficiency of heat processing methods. Light metal processing can be specially wasteful—unusual properties of aluminum, magnesium, and titanium call for an oven specifically designed to meet the application involved.

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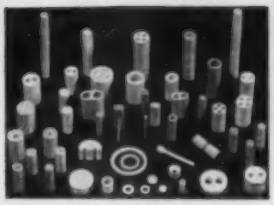

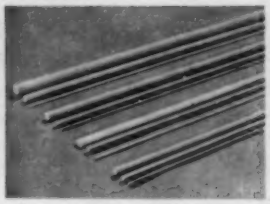

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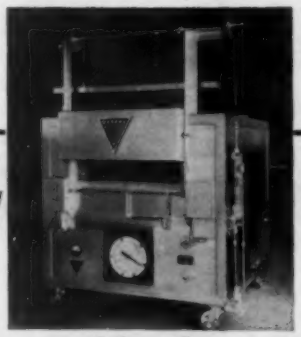

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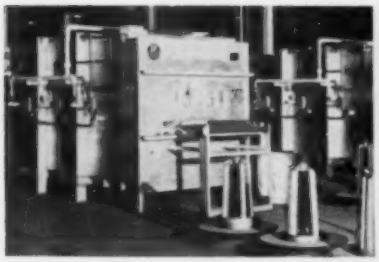
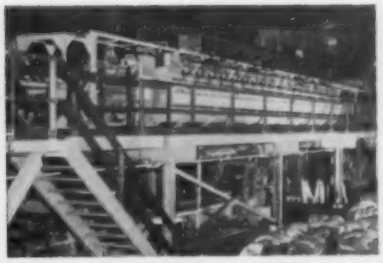
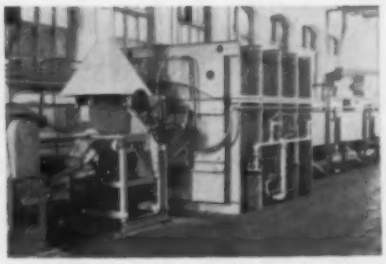


An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.

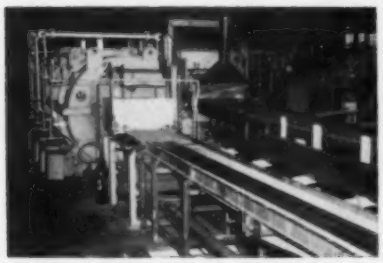


Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.

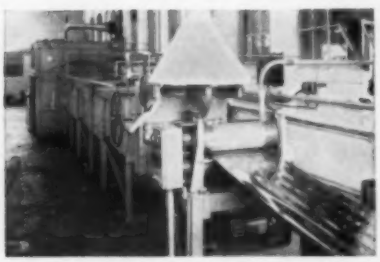


Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

# Bright Annealing Stainless



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.



Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

## Tubing, Strip, Wire, Stampings and Other Stainless Steel Products

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

**Submit your production furnace problems to experienced EF engineers — it pays.**

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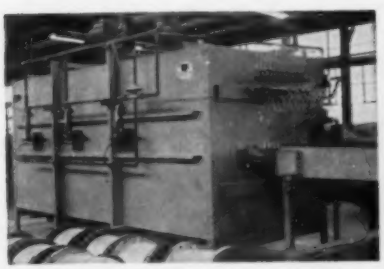
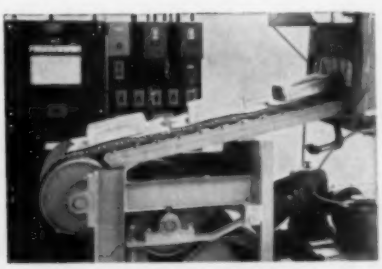
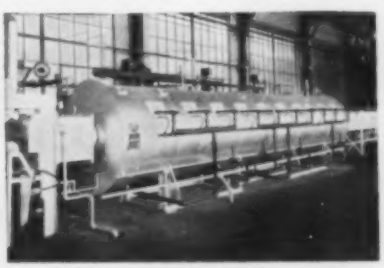


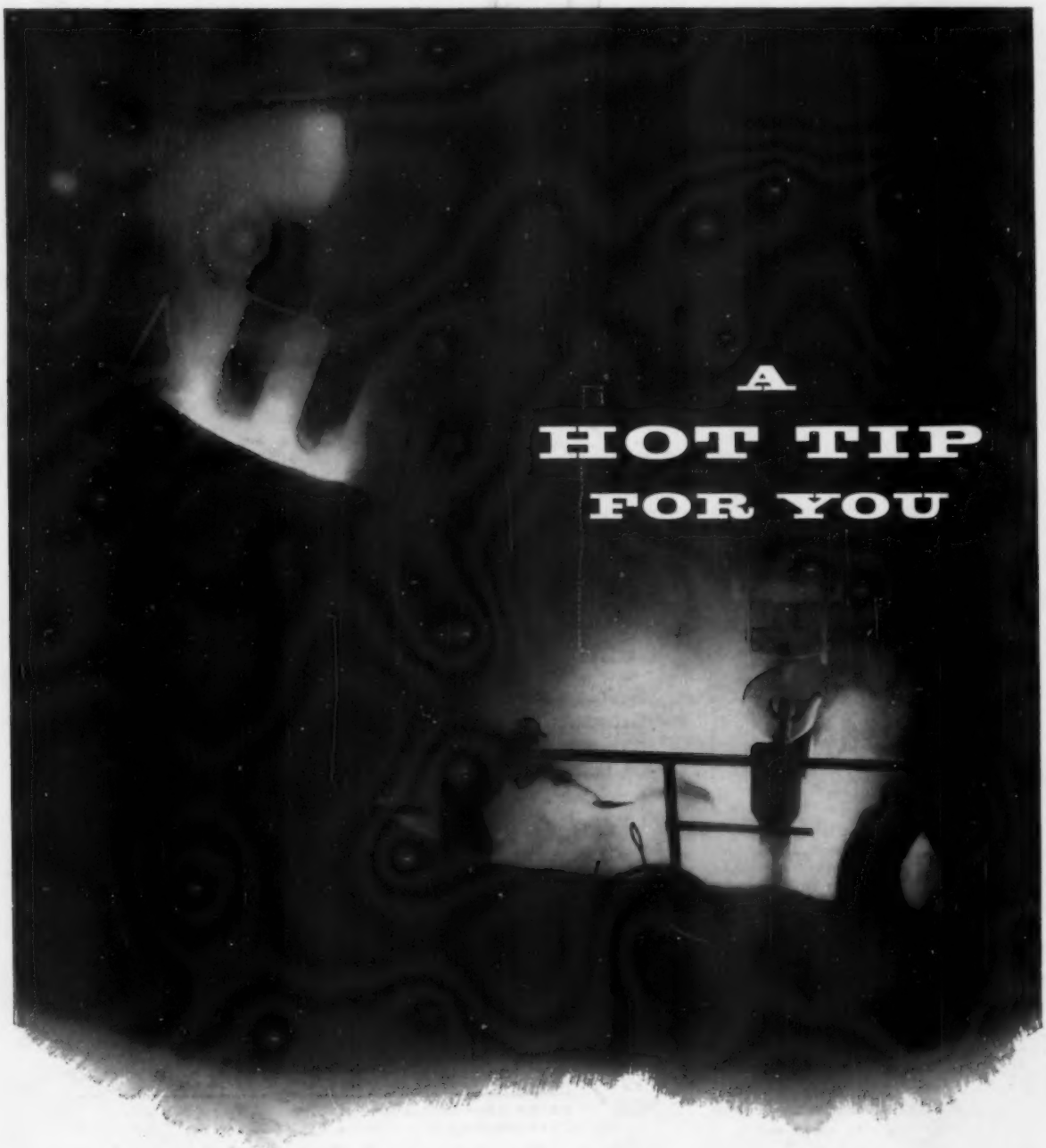
Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.




● Electric arc furnaces represent the greatest degree of refinement of any steel-producing method. More rigid metallurgical controls are possible in the electric furnace and, therefore, assure you the highest, most uniform quality in your steel. A leader in the use of the electric furnace, Copperweld offers the most diversified selection of hot-rolled blooms, bars and billets of both leaded and unleaded alloy and carbon steels.

ARISTOLOY STEELS

**COPPERWELD STEEL COMPANY**

**Steel Division • Warren, Ohio**

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